URBANISATION AND ENERGY
IN THE THIRD WORLD
A STUDY OF INDIA

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PREFACE

Urbanisation has been accelerating in many developing countries as people migrate to cities seeking work. There are now more than 275 cities in the 3rd World with population over 500 thousand.

This process of urbanisation is posing serious challenges to energy-planners. The urbanisation is bringing about a transition from traditional energy sources to modern fuels. At the same time for the urban poor, biofuels meet a major portion of their energy needs, resulting in pressure on such resources. The growth in income in urban areas is leading to increased demand for new services particularly those based on electricity. In the transportation sector, there has been an explosion of personal vehicles like cars and 2-wheelers.

A better understanding of the relationship between urban development patterns and the use of energy, both modern fuels as well as bio-fuels, will allow governments to manage better the demand and supply of these fuels.

There has been comparatively little research on urban energy use in the 3rd World countries. The present report, which looks at the use of energy in households and for urban transport in Indian cities, seeks to bridge this gap to some extent.

Work on this report has been done primarily by K.Dharmarajan, a senior officer of the Indian Administrative Service, who was during the period of this study on sabbatical from the Government of Tamil Nadu as a Visiting Senior Fellow at this Institute. In the analysis pertaining to the household sector, he was assisted by Ms Charu Puri, Research Associate at this Institute.

There have been several constraints particularly in regard to data availability. The study clearly brings out that there are several important issues which need to be addressed by urban and energy-planners in the 3rd World countries. Further, research work in several areas for obtaining information regarding patterns of energy use would be required and it would be worthwhile to explore some of the main policy issues raised in this report in greater detail.

(R.K. Pachauri)

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CHAPTER 1

INTRODUCTION

1.1 URBANISATION AND ENERGY

Urbanisation is a relatively recent but by far the most dominant social transformation of our times. The world has fast transformed itself into an urban society - and by 1985 nearly 2 billion people (41% of the total population) were living in urban settlements.

The implications of the urbanisation process and different forms of urban growth present serious challenges to the energy sector in financial, economic, technological and environmental terms. Unfortunately, not much quantitative work has been done in the developing countries to assess the overall energy implications of different patterns of urbanisation, not only with regard to future possibilities but also on the basis of past experience in urbanisation in the Third World. Most of the literature that exists on this subject, comes from work done in the developed countries. The relevance of this work hardly goes beyond raising some conceptual questions, and in no way provides an empirical basis for studying the problem in the developing countries.

1.2 ECONOMIC GROWTH AND URBANISATION

With economic growth, urbanisation is inevitable. In the world's industrial and more advanced countries urban population makes up for 78 percent of the total population. The corresponding figures for the lower-middle income countries and low income countries are 34 percent and 21 percent respectively.

The correlation between the GDP and the level of urbanisation obtained by using the data in TABLE 4.1 is 0.48 indicating that to some extent, a higher level of economic growth implies a higher level of urbanisation.

1.3 PACE OF URBANISATION

The movement of people from rural areas to cities is a significant feature of the development process in many countries of the Third World. Though most people in the Third World still live in rural areas, the proportion living in urban areas has grown between 1960 and 1984 - from 14 percent to 23 percent in low income countries and from 20 percent to 49 percent in low-middle-income countries.

In India, the urban population has risen from 62 million in 1951 to 160 million in 1981, and by 1985 might have crossed the 200 million mark. By the year 2000 India's total population may be over 1 billion and over one third of this (nearly 325 million), will be in areas. In a short span of twenty years the urban population would doubled.

1.4 IMPLICATIONS OF URBANISATION

What are the implications of this rapid pace of urbanisatio the energy scene? Urbanisation leads to:

- Shift from traditional energy sources (including human and an power) to commercial sources of energy.
- Increase in energy use on account of demand for new service households - e.g. electricity for domestic lighti refrigeration.
- Greater dependence on monetised formal supply networks to the energy demand.
- Increased requirements for personal transportation on account separation of places of work and residences.
- Greater dependence on oil based motorised forms of transport.
- Increased incomes and better living styles leading to la energy use per capita.

The energy using activities in cities can be broadly classifi into the following categories:

* Home based activities - Cooking, lighting, space and wat heating/cooling.

* Transportation of people and goods - Inter and intra city.

* Office and commercial - Lighting, space heating/cooling.

* Production of goods - Motive power, process heat.

* Provision of infrastructural facilities - e.g. water suppl street lighting, drainage etc.

There has been increasing use of commercial fuels to suppo these activities in the cities of the Third World. As these citie grow and more people move from the countryside, there will be mounti pressure on the energy supply networks. We need to have a bett understanding of the urban development process and energy consumptio patterns in cities and the relationship between them to enabl governments to plan for, and better manage the demand for fuels i urban areas.

1.5 SUSTAINABLE URBAN ENERGY SYSTEMS

We know that urbanisation is inevitable in the process of economic development. But, we need to ask ourselves:

- Is the present pattern of urban growth sustainable?
- What is the impact of this urbanisation process?
- Can we plan our cities and energy systems so as to:
  - reduce per capita gross energy requirements
  - increase efficiency of energy use
  - make greater use of renewable energy/recycled waste
  - meet the needs of the poor in an equitable manner
  - reduce environmental impact

In the long run we must shift to more sustainable systems of energy in our urban areas.

1.6 COVERAGE OF THE STUDY

In this study we first give an overview of the energy scene in India and then analyze urbanisation trends and the urban development process in India. Then we look at the energy consumption patterns in urban areas in India in the household and passenger transportation sectors. The consumption in the industrial sector is not being covered in this study since there have been other studies relating to industrial energy use. The energy use in the commercial sector and for providing infrastructural facilities has not been included since we do not have adequate data at this stage for a sufficient number of cities to draw any meaningful conclusions.

Apart from looking at consumption patterns of energy and the changes that have taken place over time, we also analyse various factors and policies that have a bearing on energy demand patterns in urban areas.

The study has been constrained by the fact that the existing database in regard to energy consumption patterns in cities in India is very limited. There have also been not many studies done earlier on the issues relating to the consequences of urbanisation on the energy consumption in the country. In this study we have attempted to put together whatever information is currently available and have supplemented this with a study on household energy carried out in ten cities/towns by the Tata Energy Research Institute (TERI).

1.7 URBANISATION IN INDIA

The specific issues that have been covered in the section relating to urbanisation in India are:

- Urban growth and imigration trends
- Regional variations in urbanisation levels and trends
- Structure of Urban development
- Income distribution of urban households

The purpose of this section is to give an overview of the urbanisation pattern in India, since this has an impact on energy consumption patterns.

1.8 ENERGY USE IN HOUSEHOLDS

The specific issues that have been covered in the study in regard to the households sector are the following:

- Analysis of energy use by:
    - Fuel Type - Firewood, dung, LPG, kerosene, coal, electricity.
    - End Use - Cooking, lighting and others.
- Variations in energy consumption patterns:
    - Between urban and rural areas
    - By income class
    - Across regions
    - Across different size of settlement
    - Over time
- Availability of fuels
- Household preferences and barriers to fuel substitution
- Use of electricity - ownership of electrical appliances
- Pricing of fuel with reference to equity, economic efficiency.

In this section we have also looked at the special problems faced by the urban poor and critical issues relating to fuelwood use in urban areas.

1.9 ENERGY USE IN TRANSPORT

The pattern of transportation in our urban centre differs from one to another and is determined by various factors including the size of the city, the employment characteristics, industrialisation, commercial growth, topography and the urban form and structure of the city. Various modes of transport are used and over a period of time there have been changes in the modal distribution as also in traffic densities. These factors have had an impact on commercial energy consumption in urban transportation systems.

In this study we look at the following with reference to some specific major cities in India:

* Total passenger trips.

* Modal split.

* Variations with reference to city size.

* Linkages between urban forms, spatial policies and transport.

* Role of public transport and policies relating to the same.

* Alternative modes in public transport.

* Scope for decrease in traffic demand as also consumption of energy.

1.10 ENERGY USE IN COMMERCIAL BUILDINGS

The category of commercial service sector includes a variety of energy uses ranging from high-rise official buildings, and restaurants to small shops and way-side establishments. There has been very little study of energy use in this sector. One needs to analyse the following in relation to commercial buildings:

* Analysis of energy use:

- By fuel type firewood, LPG, kerosene, coal and electricity.
- By end use cooking, water heating, air conditioning, lighting, lifts, laundry, miscellaneous.
- By establishment-offices, restaurants, hotels, shops, hospitals and cinema theatres.

* Air conditioning and heating loads and their effect on peak demand.

* Effect of the lighting load on the load profile.

* Use of energy in lifts.

- Growth of commercial space and energy intensity in commercial buildings.
- Architecture and building design and their effect on energy use.
- Scope for conservation.

Unfortunately there is no data whatsoever available at present relating to commercial buildings. To bridge this big data gap a survey has been initiated by TERI in 80 commercial buildings and 300 shops in Delhi. But completion of the survey and analysis of the data has not been possible within the time frame and budget of the present study.

The present study is restricted to the analysis of energy use in urban households and for urban passenger transport.

CHAPTER 2

ENERGY SCENE IN INDIA

2.1 ECONOMIC GROWTH AND ENERGY CONSUMPTION

Energy consumption is closely linked to economic growth. In India the growth in commercial energy has been faster than the rate of growth in real GDP, which was on the average 4% between 1970-71 to 1986-87. There has been therefore an increase in commercial energy intensity. The overall commercial energy intensity in the Indian economy in terms of toe/Rs million GDP has shown an upward trend from about 54 in 1970-71 to around 60 in 1987-88. This has been due to

- mechanization in agriculture for land preparation and lift irrigation;
- a shift in freight traffic from rail to road;
- increase of private modes of transport in cities;
- increased personal incomes and urbanisation leading to higher household energy use.

Further, there has been a shift from non commercial forms of energy to commercial energy sources. In India commercial energy accounts for about 60% of total primary energy supply. The supply of commercial energy has been growing faster (5.4% per year) than that of non-commercial energy (around 1.7% per year). The share of non-commercial energy has steadily declined over the years (TABLE 2.1).

TABLE 2.1: Consumption of Commercial and Non Commercial Energy

	1953-54	1960-61	1970-71	1981-82
Commercial Energy (mtcr)	60.4	101.2	197.3	309.4
Share %	32.4	41.0	53.4	60.5
Non-commercial Energy (mtcr)	125.9	145.5	172.2	201.4
Share %	67.6	59.0	46.6	39.5
Total (mtcr)	186.3	246.7	369.5	510.8

[Note: The unit used for aggregation is million tonnes of coal replacement (mtcr). If mtoe is used for aggregation the share of non-commercial energy will be higher].

Source: Planning Commission, Govt.of India.

2.2 COMMERCIAL ENERGY

The data in TABLE 2.2 gives an overview of the commercial energy supply and consumption in the last decade.

The oil shock initially had the impact of reducing energy consumption, with annual growth rate between 1975-76 to 1980-81 being only 2.7%. Oil imports rose in this period from 15.64 million tonnes to 23.4 million tonnes. However, after 1980-81 increased indigenous production of coal, gas and oil took place, and commercial energy production grew at an annual rate of 9.5%. Commercial energy consumption in the period 1980-81 to 1986-87 was going up at an annual average rate of 6.1%.

The notable achievement was a reduction in oil imports from 23.6 million tonnes to 16.04 million tonnes in this period. Had demand management and energy conservation measures been more effective the import level could have been brought down still further. Value of oil imports as a percentage of export earnings had been brought down from 78% to 24% in this period. Even so, in 1986-87 India was spending Rs. 3,050 crores in foreign exchange towards oil imports.

TABLE 2.2: Commercial Energy-Production, Supply) and Consumption

			1975-76	1980-81	1986-87
				(mtoe)	
1.	PRODUCTION		63.80	72.54	125.18
	a.	Coal	50.33	55.89	81.28
	b.	Oil	8.45	10.45 ✓	30.49
	c.	Gas	2.03	2.02	8.45
	d.	Primary Electricity	2.99	4.18	4.96
2.	IMPORTS (Net)		15.42	24.08	17.22
	a.	Coal	- 0.22	0.68	1.18
	b.	Oil	15.64	23.40	16.04
3.	NET AVAILABILITY+		59.80	68.23	97.44
	a.	Coal	33.91	31.97	41.21
	b.	Oil	20.32	28.42	40.89
	c.	Gas	0.56	0.88	3.85
	d.	Electricity	5.01	6.96	11.49
4.	CONSUMPTION		59.80	68.23	97.44
	a.	Agriculture	2.57	1.59	2.80
	b.	Industry	32.90	35.77	50.64
	c.	Transport	14.58	17.00	22.00
	d.	Residential	5.62	6.87	10.76
	e.	Others)	4.13	1.72	2.24
	f.	Non Energy Use)		5.28	8.99

+ This is net availability of secondary energy after accounting for stock changes, conversion and T & D losses.

In terms of sectoral shares in commercial energy consumption one sees that there has been no major shift. (TABLE 2.3) The household sector accounts for only 11% of energy use. (However, if non-commercial sources of energy are included households become the major user sector). Industry and transport sectors consume nearly three fourths of commercial energy. Most of the coal is used in the industrial sector (apart from power generation). Two thirds of the oil is used in the transport and household sectors. Electricity, which has been growing at a rate of 8.7% per annum, is used mostly in industry and agriculture. Gas is used mostly as a feedstock for fertiliser production. Over 90% of the commercial energy would be used in urban areas.

2.3 NON-COMMERCIAL ENERGY

As pointed out earlier non-commercial energy plays an important role in the total energy scene in India. The main source of energy is firewood which accounts for two thirds of total non-commercial energy. Agricultural wastes account for 20% and the balance comes from animal dung (TABLE 2.4). A significant portion of this energy is used in rural areas. However, about 30% of the total firewood used and about 5% of the animal and agricultural waste is for meeting needs of the urban households.

TABLE 2.3: Sectoral Share in Commercial Energy (%)

	Total Commercial Energy			Share of specific fuel in 1986-87			
	75-76	80-81	86-87	Coal	Oil	Gas	Electricity
Household	9.4	10.1	11.0	2.4	19.9	0.5	14.2
Agriculture	4.3	2.3	2.9	-	0.9	-	20.7
Industry	55.0	52.4	52.0	90.1	15.8	25.4	52.5
Transport	24.4	24.9	22.6	7.5	45.6	-	2.3
Others	6.9	10.3	11.5	-	17.8	74.1	10.3

TABLE 2.4: Consumption of Non-Commercial Energy

Year	Consumption (m tonnes)			Total	
	Firewood	Agri.Waste	Animal Waste	MTCR	MTOE
1960-61	99.6	30.6	54.6	145.5	73.2
1970-71	117.9	36.3	64.6	172.2	86.6
1981-82	137.8	42.4	75.5	201.4	101.3

2.4 ENERGY CONSUMPTION IN THE HOUSEHOLD SECTOR

In the total energy consumption - commercial and non-commercial together - the household sector accounts for the major share. In 1981-82 the total consumption in the household sector was estimated to be 109.1 MTOE which was 62% of the aggregate energy consumption. Commercial sources accounted for only 6.9% of the consumption, the rest shared by firewood (60%), agricultural wastes (16.5%) and animal dung (16.6%) (TABLE 2.5).

One sees that in the period from 1970-71 to 1981-82, while oil consumption went up by 40% and electricity use went up by 79%, there was only a marginal shift in the share of different fuels used in the household sector.

Non-commercial sources still meet 93% of the total energy demand in this sector, and firewood continued to be the major fuel used by households, meeting 60% of the needs. We will see in a later section that even in urban areas, firewood plays a major role in meeting household energy needs.

Among the commercial fuels consumed by households, oil in the form of kerosene and LPG is the most important source contributing nearly three fourth. The share of coal has been declining over the years. Electricity, which is growing at nearly 10% per year, accounted for about 12% of the commercial energy use in households. But in terms of total energy used in households the share of electricity was less than one percent.

2.5 DEMAND PROJECTIONS

Some demand projections have been made by the Planning Commission and by the coal, oil and electricity sectors. Based on the projections

TABLE 2.5: Energy Consumption in the Household Sector

Fuels	Unit	1970-71	1981-82	% age Consumption 70-71	81-82
COMMERCIAL	MTOE	5.6	7.6	6.1	6.9
Coal	MT	3.2	3.0	1.7	1.3
Oil	MT	3.7	5.2	4.0	4.8
Electricity	KWh	3.8	10.6	0.4	0.8
NON-COMMERCIAL	MTOE	86.6	101.5	93.9	93.1
Firewood	MT	117.9	137.8	60.7	60.0
Agri. Waste	MT	36.3	42.4	16.4	16.5
Animal Dung	MT	64.6	75.5	16.8	16.6
TOTAL	MTOE	92.9	109.1	100.0	100.0

the estimated demand for different sectors and the fuel mix in the year 2000 is shown in TABLE 2.6. The total energy requirements are estimated to increase to nearly 350 MTOE. In coal replacement terms The share of commercial energy will go up from the present 60% to 80%. But in energy content (MTOE) terms non-commercial energy will be meeting only two fifths of total energy demand.

In commercial energy use industry and transport will be the main sectors (56 and 33% respectively). A significant portion, of the electricity (60%) will be used by industry, while households share in electricity use will go up to about 20%. Coal, apart from the use for power generation, will mostly be used in industry. Of the total oil consumption two fifths will go to the transport sector and about one-fourth for households.

The non-commercial energy sources will be used in the household sector only and they would be meeting 83% of the total energy used in households. In terms of total energy, the household sector will be the major consumer, accounting for over one half of total energy consumption, followed by industry which will be using one third of the total energy.

The main issues before energy planners is how to meet this order of demand within the constraint of capital resources faced by the country. There is a need to move away from excessive dependence on oil. Demand management and increase in efficiency of energy use have acquired both greater significance in the context of accelerating demand and an increasing resource crunch. The importance of biofuels in the total energy mix will continue and attention also has to be paid for the development and orderly exploitation of these sources, as also increasing efficiency of use of these biofuels.

TABLE 2.6: Projections of Energy Use in 1999-2000

	H.hold	Ind.	Trans.	Agri.	Others	Total
Elec. (TWh)	81.4	249.0	8.3	40.9	44.4	424.0
Coal (MT)	14.0	151.0	7.8	-	5.2	188.0
Oil (MT)	17.7	12.0	29.9	8.1	5.0	72.7
Fuelwood (MT)	191.6					191.6
Dung Cake (MT)	105.0					105.0
Agri.Waste(MT)	59.0					59.0
			(in terms of MTOE)			
Elec.	6.8	20.8	6.7	3.3	3.7	35.3 (10.2)
Coal	6.9	78.9	3.8	-	2.5	92.1 (26.3)
Oil	17.7	20.0	29.9	8.1	5.0	72.7 (20.8)
Fuelwood	91.0					91.0 (26.0)
Dung Cake	44.1					44.1 (12.6)
Agri.Waste	14.2					14.2 (4.1)
	180.7	111.7	34.4	11.4	11.2	349.4
	(51.71)	(32.0)	(9.8)	(3.3)	(3.2)	100.0

Figures in brackets indicates shares.

TABLE 3.1: Urban Population 1901-1981

Year	Urban Population (millions)	Percentage of Urban Population to Total (%)	Decadal Urban Growth Rate (%)
1901	25.8	10.8	
1911	25.9	10.3	0.4
1921	28.1	11.2	8.3
1931	33.5	12.0	19.1
1941	44.2	13.8	32.0
1951	65.4	17.3	41.4
1961	78.9	18.0	26.4
1971	109.1	19.9	38.2
1981	159.7	23.3	46.4
2001(projected)	326.0	33.1	

Source: Office of the Registrar General, Census of India.

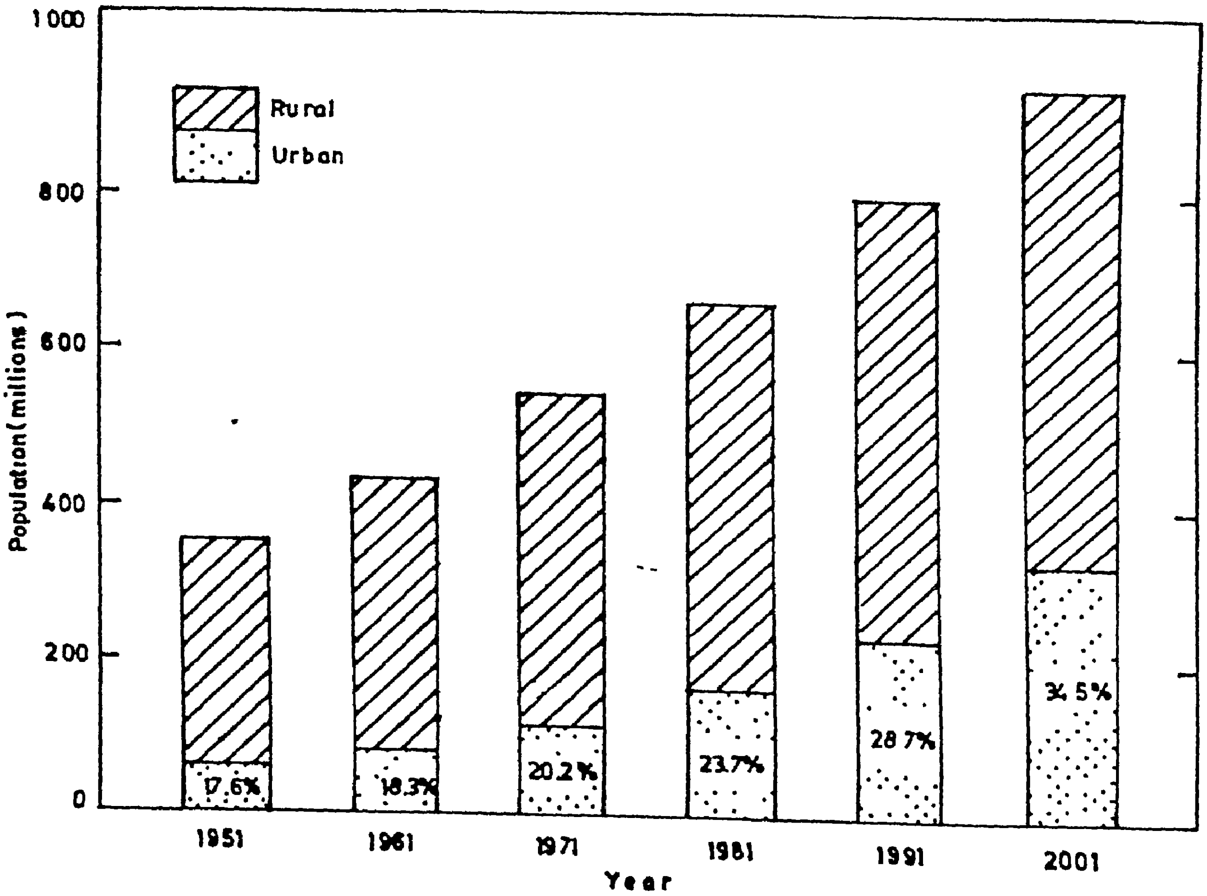


FIGURE 3.1: Urban Growth in India

CHAPTER 3

URBANISATION IN INDIA

3.1 URBAN GROWTH

The trend of urbanisation in India has been accelerating, specially in the last three decades (TABLE 3.1). In 1951 there were 65 million people in towns and cities in India (17.3% of the total population). By 1981 this had swelled to nearly 160 million--with one in every four persons staying in urban areas. By the turn of the century the urban population is expected to be 326 million--one third of the total population (see FIGURE 3.1).

In the last decade alone the number of urban dwellers has grown by 50 million, absorbing nearly two-fifths of the total population growth in this [illegible] decade. The decadal urban growth rate was 46.4%--that is 3.9% per annum compounded. Compare this with the rates in industrial market economies(1.4%) and the East European economies(2.6%). It is anticipated that the present urban growth rate will continue in the twenty year span from 1981 and urban population in India will double in this period.

An analysis of the different components of urban growth shows that natural increase contributed about two-fifths, net immigration another two-fifths, and reclassification(new towns and area changes) about one fifth to the urban population growth in the 1971-81 period. That is, out of a net increase of 50.6 million in the urban population, 20.6 million was contributed by natural increase and 20 million by net immigration.

3.2 LEVEL OF URBANISATION

In terms of its share in the total population India's urban population (23.3%) is somewhat higher than of China (21%), but only one-third of the level in the United States (70%). A majority of developing countries are more urbanised than India - in fact out of ninetyfour low-and middle-income developing countries sixty surpass India in terms of percentage of urban population.

TABLE 3.2: Levels of Urbanisation and Development

Economic Parameters X ->	X(1)Industrialisation		x(2)Diversification		x(3)Income	
Groups of countries	No.	%age	No.	%age	No.	%age
Higher in both U and X(i) than India	50	55	52	57	52	66
Lower in both U and X(i) than India	23	25	22	24	10	12
Higher in U but lower in X(i) than India	10	11	8	9	3	4
Lower in U but higher in X(i) than India	8	9	9	10	15	18
Total (excluding India)	91	100	91	100	80	100

Source: NIUA. (1988) pg. 5

U = Percentage of urban population (= 24 for India)
X(i) = Percentage of Industrial Workers (= 13 for India)
X(2) = Percentage of Non-agricultural workers (= 29 for India)
X(3) = Per Capita GNP (US$ 260 for India)

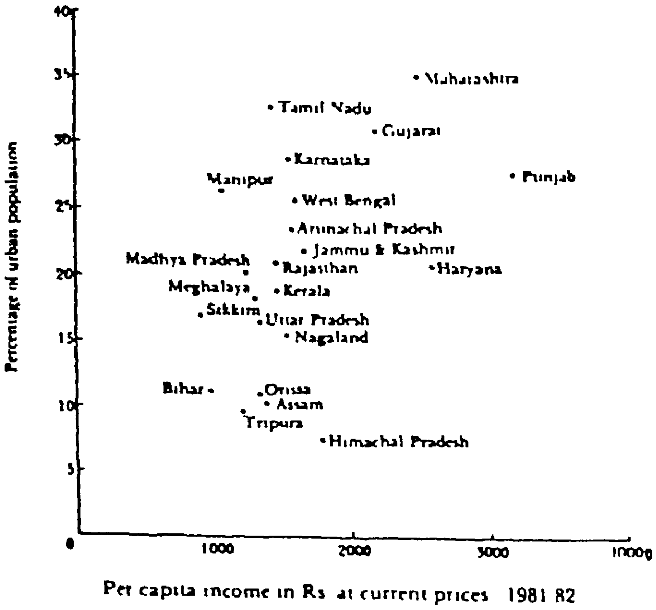


FIGURE 3.2: Level of Urbanisation and State Per Capita Income

A critical look at the data relating to India in comparison with ninety four low and middle income economies shows that, seen in the light of certain economic parameters like industrialisation, diversification of the economy and levels of income, Indian urbanisation is in line with the conditions prevailing in about 80 percent of the developing countries (TABLE 3.2).

3.3 URBANWARD MIGRATION

The migrant population of India in 1981 was 204 million, showing an increase of 22 percent over the 1971 figure. The rate of increase of migrants to urban areas was more than twice, being 48 percent. This indicates the fair degree of mobility of the Indian population. As is to be expected employment in the case of males, and marriage in the case of females are the principal causes of migration.

Migration contributed about 40 percent to the urban growth during the 1971-81 period. Of the total 34.1 million urban migrants in this period 17.4 million were from rural areas, 13.5 million from other urban areas and 3.2 million from outside the country.

3.4 RURAL URBAN DISPARITIES

Not only has there been an increasing rural-urban migration but the rural urban economic disparities have also widened over time. The differential between the rural and urban per capita net domestic product which was 1:1.8 in 1950-51 had increased to 1:2.9 by 1980-81. It is expected that the gap will widen further, and by 1994-95 the ratio will be around 1:3.3.

The implications of this on the energy scene are obvious - increased incomes and more modern life styles leading to rapid increase in commercial energy use.

3.5 CORRELATES OF URBANISATION

A correlation exercise of urbanisation and development levels in different States in India reveals that the urbanisation levels of different states are significantly related to their per capita net domestic product(r=.61) (see FIGURE 3.2). This relationship is stronger with the income generated in the secondary sector(r=.69) than that in tertiary sector(r=.61). The correlation with the primary sector is low (only .09). This shows that there is a link between economic development of the state and its level of urbanisation. Dominance of the primary sector is invariably associated with low levels of urbanisation. Any shift in favour of the secondary sector invariably raises the level of urbanisation.

Both birth and death rates (r = -0.29 and r = -0.34) show a negative relationship and access to water supply (r = 0.71) and sanitation (r = 0.69) a positive relationship with the level of urbanisation.

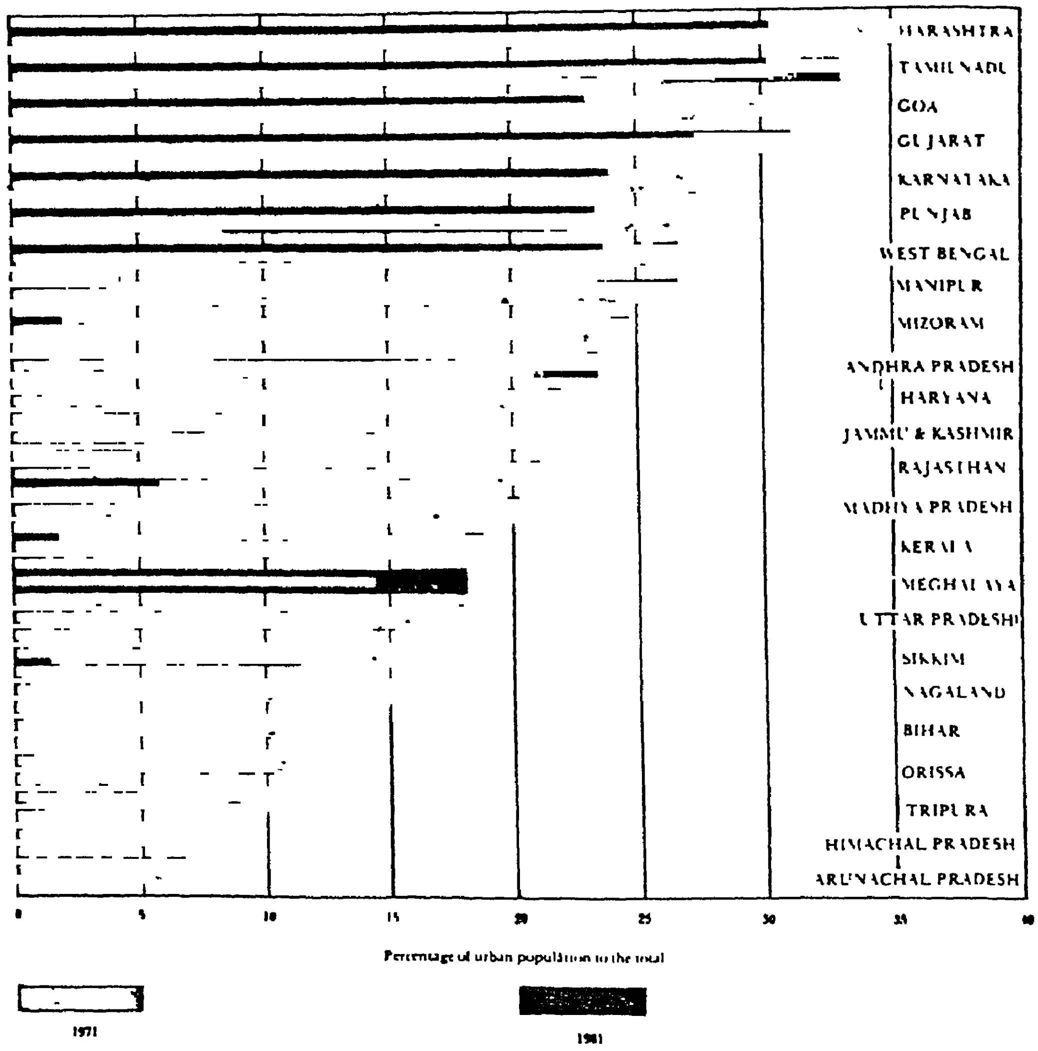


FIGURE 3.3: Level of Urbanisation by States 1971 and 1981

TABLE 3.3: Decadal Urban Growth Rates(%)

States	'61-'71	'71-'81	States	'61-'71	'71-'81
Uttar Pradesh	30.7	60.6	Maharashtra	40.8	40.0
Bihar	44.0	54.8	West Bengal	28.4	31.7
Madhya Pradesh	46.6	56.0	Tamilnadu	38.6	28.0
Rajasthan	38.5	58.7	Gujarat	41.0	41.4
Andhra Pradesh	33.9	48.6			

TABLE 3.4: Urbanisation Levels in Districts in 1981

	With percentage of Urban Population					
	Over 50	Over 33.3 but <50	Over 23.7 but <33.3	Over 10 but <23.7	<10	Total
Number of Districts	18	35	62	173	114	402*
Percentage to Total	4.5	8.7	15.4	43.0	28.4	100

Source: Census of India, 1981

* Excludes districts in Assam and ten entirely rural districts.

An analysis of the change in economic and employment structure over the last 30 years shows that the productivity of the manufacturing and service sectors, representing the urban segments, has risen much higher than that of the primary sector, representing the rural segment.

All this indicates that urbanisation has helped the process of economic development and social change. We can say that as India develops not only will increased urbanisation be inevitable but may in fact, be desirable. But, two questions arise: First is the present pattern of urban growth appropriate from the point of resource optimization. Second, what are the implications of this urbanisation on infrastructure (for example on the energy system) and are our policies geared to meet this demand.

3.6 REGIONAL VARIATIONS

The aggregate figures for India can be misleading· unless one considers the distribution of the urban population among the different States. At one end of the spectrum we have States with low levels of urbanisation like Arunachal Pradesh(urban population share 6.6%) and Himachal Pradesh(7.6%), and at the other end Maharashtra(35%) and Tamilnadu(33%). The regional disparities in urbanisation and the change in the last decade is shown in FIGURE 3.3.

In terms of the number of people living in urban areas the leading states are Maharashtra(22 million), Uttar Pradesh(20 million), Tamilnadu(16 million), West Bengal(15 million), Andhra Pradesh(13 million), followed by Karnataka, Gujarat and Madhya Pradesh (about 11 million each). Interestingly, of these eight leading urban states, the proportion of urban population to total is lower than the national average(23.3%)in Uttar Pradesh, Madhya Pradesh and Andhra Pradesh. These states have a large agricultural sector but nevertheless have a large urban population. This urbanisation is not so much induced by economic activity as by sheer increase in population.

Even in terms of decadal growth rates the range of variation among states is striking. In the rural states of Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan and Andhra Pradesh there has been an acceleration of the urban growth rates as is revealed by TABLE 3.3.

On the other hand in the traditional urban states like Maharashtra, West Bengal and Tamilnadu the urban growth is stagnating. In Tamilnadu, the urban growth rate even declined from 38.6 to 28.0%. This indicates a trend in reduction in regional disparities in regard to urbanisation. However, the regional disparities in urbanisation is still quite marked as is revealed in TABLE 3.4. This shows that over seventy percent of the districts had levels of urbanisation below the national average of 23.7 percent (excluding Assam).

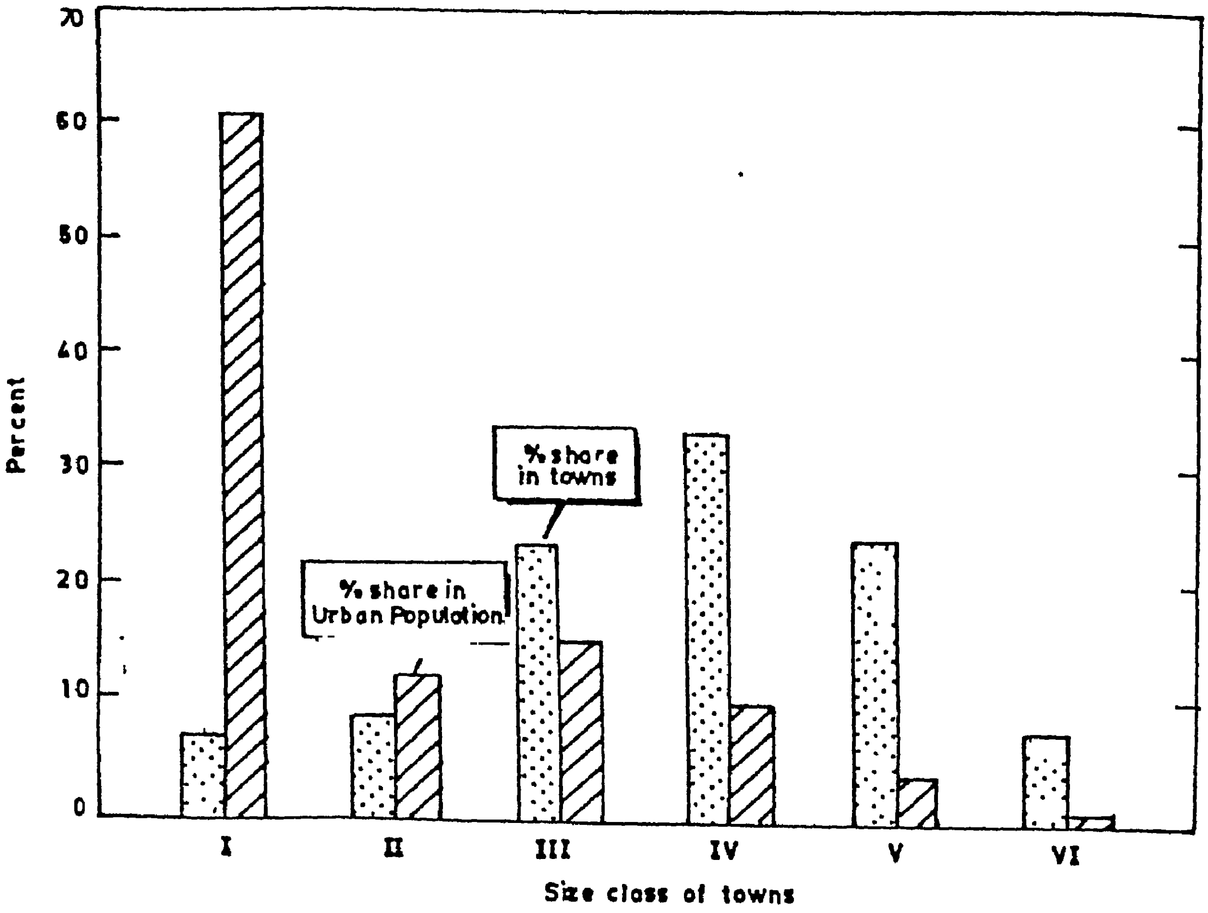


FIGURE 3.4: Distribution of Urban Population by Size Class

TABLE 3.5: Classwise Distribution of Towns

	No. of Towns in Each Size-Class of Towns						
YEAR	I	II	III	IV	V	VI	Total
1901	25	44	144	427	771	503	1914
1911	26	38	158	388	750	546	1906
1921	29	49	172	395	773	626	2044
1931	31	59	218	479	849	580	2216
1941	49	88	273	554	979	478	2421
1951	76	111	374	675	1195	628	3059
1961	104	128	451	737	743	208	2371
1971	147	178	573	850	656	170	2574
1981	218	270	743	1059	758	253	3301

Source: 1901-1951: Alam S.M. (Ed.) (1987) pg.109 Table 2
1961-1981: National Institute of Urban Affairs

3.7 STRUCTURE OF URBANISATION

There is also a skewness of distribution of population among different cities with a high concentration of the urban population in a few large cities. (see FIGURE 3.4). India's twelve metropolitan cities(each with population over 1 million) account for one fourth of the urban population. Fortytwo cities (each with a population over half a million) accommodate nearly two fifths of the urban population. Among the metropolitan areas, Bangalore and Delhi urban agglomerations were growing at the fastest rate--decadal growth rates being 76.1% and 56.7% respectively.

In all, according to the 1981 census, there were 3301 towns/urban agglomerations. These include 218 cities (population exceeding one lakh), 1013 medium towns(population between twenty thousand and one lakh) and 2070 small towns.

What about the distribution of population among these categories of towns?

Over 60% of India's urban population lives in its cities. Medium towns account for about one fourth of the urban population and the remaining 2070 small towns share less than 15 per cent of the urban population. Over this century the structure of urbanisation has been changing significantly with increasing concentration towards larger cities (TABLES 3.5 and 3.6). Urban growth has occurred mainly in the 'over-one-lakh' cities (i.e. class I cities). Such concentration in the largest cities continues a progressive shift in the pattern of urbanisation which has been going on in India since 1901 (see FIGURE 3.5).

The growth in number of towns has not kept pace with growth in urban population. There is a tendency to agglomerate population in the towns established earlier instead of creating new towns to that extent. Number of class V towns have remained stagnant and there has been a decline in the number of class VI towns. (In the last decade one does see an increase in Class V and VI towns. This may be due to some definitional changes or because of villages outgrowing into a town status through natural increase in population.)

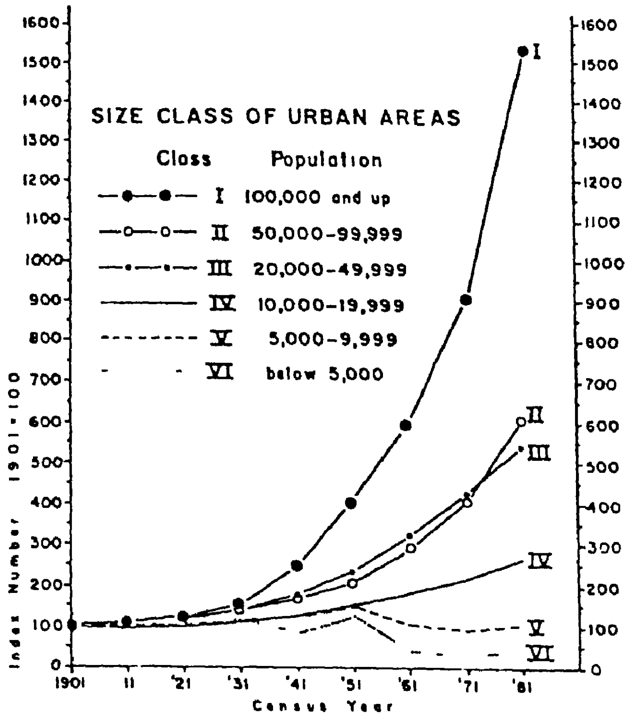
In terms of share in total population class IV and smaller towns (i.e.less than 10,000 population)show a steady decline. Share of class II and III towns (i.e. population 20,000 to 1 lakh) has remained somewhat steady, while class I cities have progressively increased their share in urban population, reaching over 60% in 1981. This trend is likely to continue unless some policy measures are taken to reverse it.

We will see later that energy consumption patterns in the household and transport sector vary with city size. Hence the continuing shift towards larger cities will have its adverse impact on the urban energy scene.

TABLE 3.6: Population Distribution by Class of Towns

	% Urban Population by each size					
YEAR	I	II	III	IV	V	VI
1901	22.9	11.8	16.5	22.1	20.4	6.3
1911	24.2	10.9	17.7	20.5	19.8	7.0
1921	25.3	12.4	16.9	18.9	19.0	7.4
1931	27.4	12.0	18.8	19.0	17.3	5.6
1941	35.4	11.8	17.7	16.3	15.4	3.5
1951	41.8	11.1	16.7	14.0	13.2	3.2
1961	48.4	11.9	18.5	13.0	7.2	1.0
1971	55.8	11.4	16.3	11.3	4.7	0.5
1981	60.4	11.5	14.3	9.5	5.7	0.6

Source: "Basic Statistics relating to the Indian Economy; Vol. 1 All India", CMIE, August 1986.



Based on Figure 5 Census of India 1981 Provisional Population Totals Paper-2 of 1981 Rural-Urban Distribution

FIGURE 3.5: Growth of Urban Population by Size Class

3.8 URBAN DENSITY

The area of urban places increased from about 42,600 sq.kms in 1971 to 52,500 sq.km in 1981. This increase was due to emergence of new towns (6,700 sq.km) and expansion of existing towns (4,700 sq.km). The area increase was less compared to population increase leading to a 20 percent increase in density from 2500 persons per sq.km. in 1971 to a level of 3000 in 1981. This density exceeds 6,000, if worked out only for the developed part of urban land. The residential density of urban India is as high as 18,000 persons per sq.km.

Cities with a population of over 1 lakh have population densities which are thrice the average of the country. The population density exceeds 20,000 persons per sq.km. in four cities; ranges between 10000 and 20,000 in 34 cities and between 5,000 and 10,000 in 87 cities.

The density of metropolitan cities (over 1 million population) tends to be even higher - average around 9,000. Ahmedabad shows the highest density (25,900) followed by Bombay (18,800), Calcutta (10,800) and Delhi (10,600).

A study of the land use data of 407 towns and cities by the Town and Country Planning Organisation, New Delhi reveals that only 46.6 percent of the urban area is developed. Further, over 15 percent of this developed land is vacant. This perhaps indicates the potential of the capacity of the towns to accomodate future growth of population without further extension of territorial jurisdication.

3.9 URBAN SLUMS

It has been estimated that nearly one fifth of India's urban population lives in slums--30 million of the total 160 million. The share of slum population is related to the size of towns/ cities. In the small and medium towns (population less than a lakh) the share is about one-tenth. The metropolitan (over a million people) cities have almost one-third of their population in slums. In some cities this proportion can be nearly one-half, for example, the Delhi urban area.

The urban poor in these slums have acute problems in meeting their energy needs. Any rational policy should pay specific attention to the needs of these slum dwellers.

3.10 INCOME DISTRIBUTION

Some idea of the income distribution can be obtained from the quinquennial consumer expenditure survey conducted by the National Sample Surveys Organization. The latest round for which data has been published is the 38th round relating to 1983. On an aggregate basis one can see that the households in urban areas are better off than those in rural areas (**TABLE 3.7** and **FIGURE 3.6**). These figures relate to consumer expenditure. But in the absence of income data income class wise, one has to rely on expenditure data.

TABLE 3.7: Distribution of Consumer Expenditure

	No.of villages/urban blocks surveyed	No.of households surveyed	%age of households with monthly per capita expenditure of						
			0-50	50-100	100-150	150-200	200-250	250-300	>300
Rural	7399	75913	7.8	43.6	27.3	10.8	4.7	2.3	3.5
Urban	4327	41983	1.8	22.5	26.9	16.9	10.3	6.8	14.8

Source: NSSO 38th Round. See GOI (1986 b).

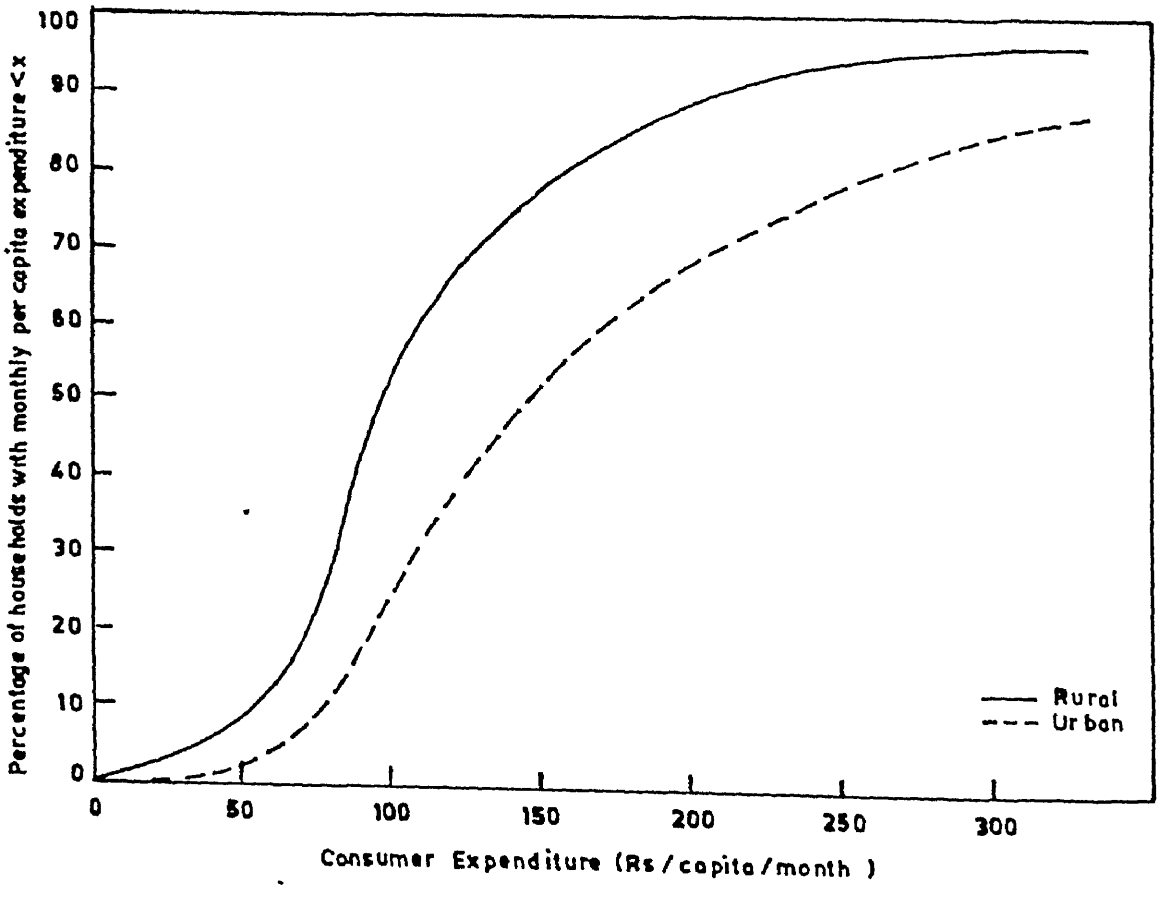


FIGURE 3.6: Distribution of Households by Per Capita Expenditure

Over a decade, as the economy has grown and prices have changed there has been a shift in the distribution of consumer expenditure. A comparison with surveys of previous rounds brings this out (TABLE 3.8). In 1973 only 5% of urban households had per capita expenditure greater than Rs. 200 per month while 17.5% of the households had per capita less than Rs. 35 per month. By 1983 there was a negligible proportion in the lowest category while nearly 32% of households were spending more than Rs. 200 per capita per month.

However, one must hasten to add that this is not indicative of any reduction in disparities in urban income. A study of the share of total consumer expenditure by fractile group (TABLE 3.9) shows only a marginal reduction in disparity. Further, there is no significant difference between rural and urban areas in terms of disparities in income distribution.

TABLE 3.8: Change in Expenditure Distribution 1973-1983

		(Percentage of Urban Households with Per Capita Monthly Expenditure less than Rs:)				
NSS Round	Year	35	100	150	200	300
27	1972-73	17.5	78.6	91.1	95.7	na
28	1973-74	9.3	74.4	89.3	95.0	na
32	1977-78	5.0	59.8	79.6	89.0	na
38	1983	0.5	24.3	51.2	68.1	85.2

Source: GOI, 1986 (a) and (b)

TABLE 3.9: Inequality in Expenditure

	Share of Total Consumer Expenditure of Bottom Fractile Group below (%)					Top Fractile
	10	30	50	70	90	10
Urban						
1953-54	2.8	11.8	24.9	42.8	70.9	29.1
1977-78	3.4	13.6	27.5	46.0	72.5	27.5
Rural						
1977-78	3.6	15.0	29.6	48.1	74.4	25.6

Source: CMIE "Standard of living of the Indian People" February 1988, page 8.3

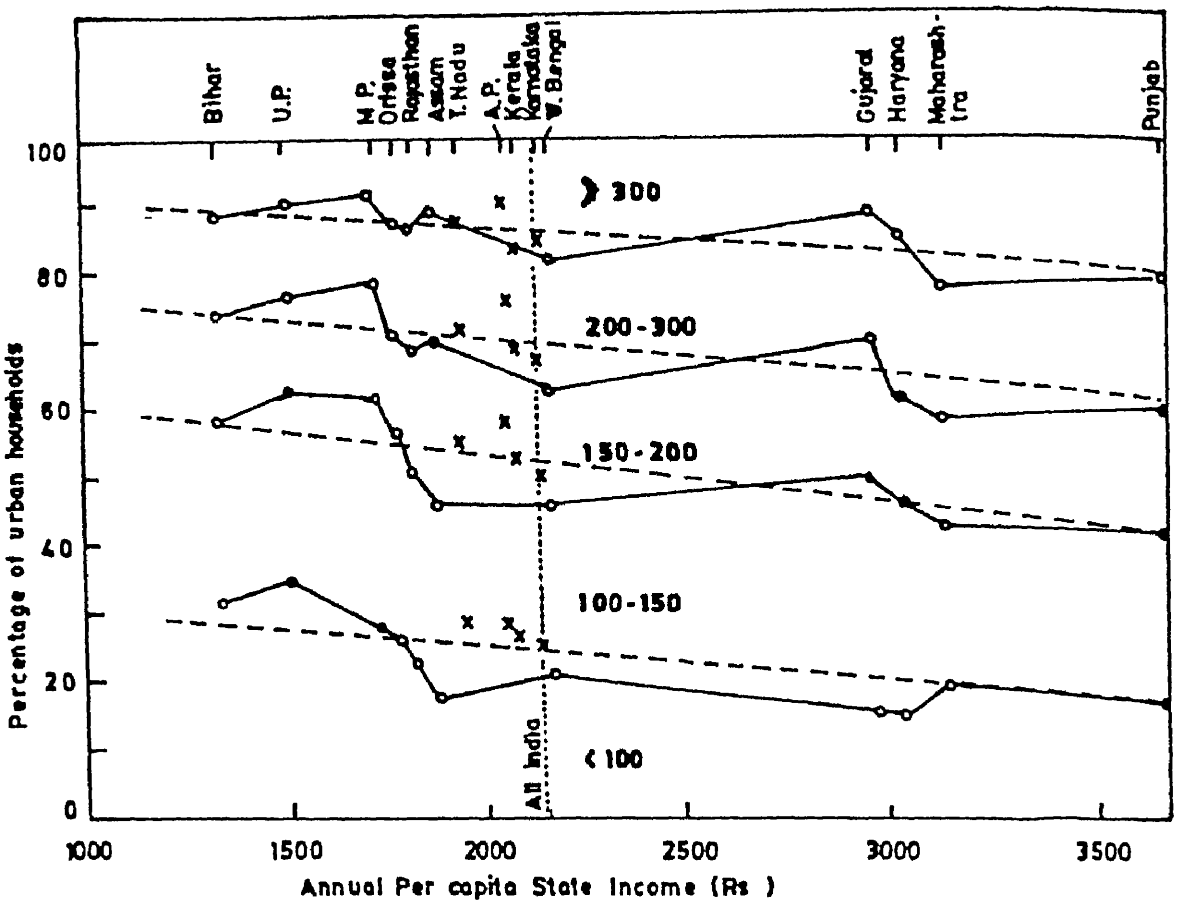


FIGURE 3.7: Consumer Expenditure Distribution of Urban Households for Different States

TABLE 3.10: Distribution of Households by Income for Specific Cities

City	Estimated No.of households in the city ('000)	No.of households surveyed	Percentage of households with Household income			
			0-350	351-750	751-1500	>1500
Jaipur	152	1293	13.7 (13.5)	42.8 (36.8)	28.3 (36.8)	15.3 (12.9)
Lucknow	168	1254	22.2 (24.0)	42.6 (38.0)	24.7 (28.4)	10.5 (9.6)
Nagpur	225	1229	24.5 (18.1)	41.2 (42.1)	23.9 (29.8)	10.4 (10.0)
Kanpur	270	1317	25.7 (24.0)	45.0 (38.0)	23.1 (28.4)	6.3 (9.6)
Pune	294	1321	15.9 (12.9)	31.5 (30.1)	34.0 (35.6)	18.6 (21.4)
Ahmedabad	421	1420	12.9 (7.0)	41.6 (41.7)	32.2 (38.9)	13.4 (12.4)
Bangalore	427	1182	16.1 (16.6)	32.1 (33.6)	34.0 (34.8)	17.7 (15.0)
Madras	725	1772	29.9 (18.6)	34.1 (37.0)	25.3 (32.2)	10.7 (12.2)
Delhi	1044	1913	16.8 (12.9)	39.3 (30.1)	28.3 (35.6)	15.7 (21.4)
Calcutta	1582	2977	27.5 (12.6)	39.1 (33.6)	22.2 (37.0)	11.2 (16.8)

Figures in brackets indicate the figures for the entire urban area in the corresponding State (according to consumer expenditure category.

It is interesting to see the regional variations in the distribution of consumer expenditure in urban areas (FIGURE 3.7). There is considerable regional disparity among States in annual per capita income with Bihar (Rs. 1331) being the poorest and Punjab (Rs. 3720), the richest. A majority of the States are below the national average per capita income of Rs. 2143 per year. Three States - Gujarat, Haryana and Maharashtra - are grouped together around Rs. 3000, while Punjab is significantly higher at Rs. 3720.

As is to be expected, as a State becomes economically better off the households in urban areas are also better off. The four Southern States - Andhra Pradesh, Karnataka, Kerala and Tamil Nadu - seem to be a little different from the normal pattern with their urban population being worse off compared to the States with similar per capita income. From FIGURE 3.7 we can get an idea of 'income' distribution among urban households for different levels of per capita State income. These estimates are summarised in TABLE 3.11.

To what extent can the State level figures be adopted for specific cities? There is very little data on income available at specific city level. However, recently a market research bureau conducted a survey of income distribution in metropolitan cities in connection with some other study. This data is summarised in TABLE 3.10. Alongside we also show the corresponding figures for urban areas in the corresponding state obtained from NSS 38th round. In some of the cities we note a fair amount of agreement between the two sets. One notes that the size of the city does not influence the income distribution as much as the economic level of the state in which the city is situated. Thus, in the absence of better data, as a first approximation we can adopt State level figures as in TABLE 3.11 when we want to look at income distribution in urban areas.

We also notice that in the 'jumbo' cities - Delhi, Madras, Calcutta the urban households are worse off than the State urban averages, perhaps reflecting the larger percentage of urban poor living in slums.

TABLE 3.11: Distribution of Households among different consumer Expenditure levels (Estimated from Fig. 3.7)

	Percentage of Households with Annual Household Expenditure of Rs.				
For States with per capita income of	3000-6000	6000-9000	9000-12000	12000-18000	>18000
1300	30	28	14	18	10
1500	27	28	15	18	12
2000	24	27	17	18	14
2500	21	26	18	18	16
3000	18	26	20	18	18
3700	15	25	22	18	20

3.11 PROJECTIONS OF URBAN POPULATION

Subsequent to the 1981 census, two projections based on rigorous analysis of data, are available for India's population in 1991 and 2001 The first is that of the Task Force on Housing and Urban Development set up by the Planning Commission. The second is that of the Expert Committee on Population Projections set up by the Registrar General, Census of India. Besides these we have a projection made by the United Nations in 1980. Their projections are summarised in TABLE 3.12.

If one goes by past experience, both the projections of the Planning Commission and Registrar General of Census may be underestimates and India may well have to manage an urban population greater than 326 million by the turn of the century.

There is no doubt that there will be at least a doubling of urban population in a short span of twenty years. The impending magnitude of the urbanisation problem is evident. Hence the imperative need to take a critical look at how resources are used to meet the needs of urban areas. In this study we direct our attention to the use of energy in urban households and urban transportation.

TABLE 3.12: Urban Population Projections

Source	Year of Projection	Estimated Urban Population (Million) 1981	1991	2001
United Nations	1980	155	236	361
Task Force	1983	159 (actual)	234-235	315- 320
Expert Committee	(undated)	159 (actual)	230	326

CHAPTER 4

ENERGY FOR URBAN HOUSEHOLDS

4.1 INTRODUCTION

In this chapter of the report we would be looking at the effects of urbanisation on household energy patterns. We will first look at the factors that may affect the levels and patterns of urban household energy consumption at the macro level. This analysis will then be supplemented by an analysis of consumption patterns at the micro level in some of the Indian cities.

4.2 PROBLEMS OF DATA

There is a great deal of variation in level of energy use as also in fuel-mix used in urban households. This is apparent when we compare national averages for different countries and averages for different States within India. The variations between one urban area and another within the same State are also often significant.

Intuitively, we can say that the following factors could influence the level of energy use and the mix of fuels:

- Household income;
- Household size, because of economies of scale;
- Availablity of and accesability to modern fuels and related end-use equipment;
- Settlement size, since availability of modern fuels is sometimes dependent on this;
- Relative prices of different fuels;
- Convenience in terms of usage, handling and storage;
- Efficiencies of different end-use equipments;
- Climatic factors, which influence energy requirements for space and water heating;
- Culture, habits and tradition;

Not only is the list long, but many of the variables (e.g. convenience, culture, habits etc.) are not even quantifiable. The factors are often interrelated and the relationship is complex. Further, in most developing countries data availability is very poor. Nationally representative surveys often miss out on the important factors influencing energy use. Detailed energy surveys, on the other hand, are often for small samples and any generalisations on the basis of these surveys is risky. Repeat surveys for the same urban areas at different points of time are also not available, and any form of trend analysis (save on a very aggregate basis) is therefore not feasible. Hence, formulating any rigorous model for understanding and forecasting urban household energy demand is, at this stage, not possible.

In spite of the constraints and data limitations mentioned above, we can still gain useful insights into household energy consumption by looking at some measures of household energy consumption in relation to some key variables - like rural-urban differences, household income, settlement size etc.

4.3 COMPARISON BETWEEN COUNTRIES

In order to establish the relationship between the level of economic development (and urbanisation) with pattern of energy use in households we start with a comparison of the nature of energy consumption among countries - both developing and developed. (TABLE 4.1).

TABLE 4.1: Household & Commercial Energy Comparison Between Countries

Country	Per-capita GNP	Urbanisation	Traditional	Liq. Fuels	Electricity Per capita	Per Capita Energy Use in Household and Commercial	
	US($)	(%)	(%)	(%)	(KOE)	Gross (KOE)	Useful (KOE)
INDIA	260	24	87.2	7.3	4	120	21.8
PAKISTAN	380	29	70.7	18.4	6	101	26.3
KENYA	390	15	95.9	3.5	4	531	74.2
INDONESIA	580	22	84.6	10.5	2	342	66.3
EGYPT	690	45	19	70.2	7	69	35.1
THAILAND	790	17	83.2	13.6	9	274	55.0
PHILLIPINES	820	38	62.7	32	15	278	83.1
ZIMBABWE	850	24	79.4	0.6	27	408	89.3
NIGERIA	860	21	97	1.7	5	362	48.7
I.COAST	950	42	94.5	3.1	6	267	39.1
JAMAICA	1330	48	1.4	85.7	17	135	80.1
COLOMBIA	1460	65	86.3	7	31	575	106.8
REP.OF KOREA	1910	61	57.9	9.1	22	960	309.2
CHILE	2210	82	43.3	35.3	26	193	75.7
BRAZIL	2240	69	61.1	22.1	36	233	71.5
MEXICO	2270	68	14.3	62.8	35	177	94.1
ARGENTINA	2520	83	19.9	43	47	340	171.5
VENENZULA	4140	84	45.2	23.2	81	407	155.9
U.K.	9660	01	0	22.4	221	989	593.4
JAPAN	10080	78	0	63.2	129	550	330.0
FRANCE	11680	79	0	56.5	154	936	561.6
F.R.G	12460	85	0	56.3	211	1214	728.4
USA	13260	78	0	31.4	496	935	561.0

A simple regression exercise using the data in TABLE 4.1 yields the following results:

Dependent Variable	Independent variable	Coefficient		t statistic		R^2
		Const.	X	Const.	X	
1. Gross energy per capita	GNP per capita	268.7	0.06	1.28	5.49	0.61
2. Useful energy per capita	"	29.1	0.05	0.37	11.81	0.88
3. Urban Population (% to total)	"	39.0	0.004	1.92	4.18	0.48
4. Gross energy per capita	Urban Pop.Share	156.7	5.98	0.54	2.51	0.25
5. Useful energy per capita	"	-85.2	5.24	-0.50	3.75	0.43
6. Share of liquid fuels	GNP per capita	13.6	0.003	0.83	3.62	0.41
7. Share of Biofuels	"	78.4	-0.007	4.02	-7.31	0.74
8. Electricity per capita	"	-11.9	0.003	-0.20	3.62	0.76

What we see from the above analysis are the following:

- A fair correlation between gross energy per capita and GDP per capita of a country;
- A high correlation between useful energy consumed per capita and GDP per capita;
- As countries became more developed there is a greater degree of urbanisation. Consqeuently a correlation between energy use and urbanisation;
- Lesser developed countries depend predominantly on traditional energy sources (biomass based);
- Share of liquid fuels in total energy use in households rises with income;
- Greater demand for electricity with rise in income, usually to meet household services other than cooking.

So with economic development, not only is the quantum of useful energy consumed per capita higher, but the fuel mix changes - with a shift away from traditional fuels. Liquid fuels, which are cleaner and more efficient, are demanded for cooking. Further, there is an increasing demand for new services, mostly based on electricity.

The difference in pattern of energy consumption that we see between developed and developing countries is similar to the comparisons between energy consumption patterns in rural and urban households.

4.4 COMPARISON WITH SOME ASIAN COUNTRIES

Before we proceed to a detailed analysis of household energy use in India, let us look at the comparative situation in some Asian countries. Leach (1986) has made comparisons using national surveys done in India, Pakistan, Bangladesh and Sri Lanka. TABLE 4.2 provides a summary of average fuel consumption in households derived from these surveys. One can see a fair amount of conformity between some of the countries, except for Sri Lanka. One notes the following:

- In rural areas over 90% of household energy needs are met by biofuels;
- Total energy used per person is lower in urban areas compared to rural areas;
- Even in urban areas biofuels play a major role in meeting household energy needs;
- Firewood is an important fuel both in rural and urban areas, meeting more than half the energy requirements;
- In terms of share of firewood to total energy there is not much difference between rural and urban areas;

TABLE 4.2: Average Household Energy Consumption Comparison among South Asian countries

		Total Energy	Total Modern Fuels	Total Bio-Fuels	Firewood	Share of Biofuels	Share of Firewood
		(M Cal per capita per month)				(%)	
Rural:							
India	1979	96	5	91	47	95	49
Pakistan	1979	95	8	87	65	92	68
Bangladesh	1977	n.a.	n.a.	100	37	na	na
Sri Lanka	1982	172	12	160	154	94	90
Urban:							
India	1979	75	27	48	35	66	47
Pakistan	1979	62	28	34	29	54	47
Bangladesh	1980	n.a.	n.a.	63	49	na	na
Sri Lanka	1982	135	15	120	119	89	88

Source: Leach (1986) Table 2.1

- Firewood use in Sri Lanka is higher presumably because of greater availability of this fuel

FIGURE 4.1 shows that income and urban rural location are important factors that influence pattern of energy use. In rural areas energy use increases steeply across the whole income range. In urban areas the energy use is lower than in rural areas for every income group. A saturation seems to be reached in the higher income groups. This is perhaps due to the fact that with rising incomes urban families switch from biofuels to more efficient and cleaner fuels - first to kerosene and later to LPG. In rural areas biofuels account for 90-95% of total energy and this hardly declines with income. On the other hand, in urban areas in Pakistan and India, biofuels share falls steeply with income from 80% to about 35%. Sri Lanka is an exception, with biofuels share showing only a marginal decline with income (FIGURE 4.2)

The data for four cities viz. Kuala Lumpur, Manila, Bangkok and Hyderabad (see TABLE 4.3) gives some idea of the fuel transition (for cooking) as household income increase. This data illustrates that the use of LPG is mainly by the richer households. Further, use of LPG and electricity is more common in the wealthier cities, reflecting the correlation between economic status and the use of these fuels by households.

At the lower income category, LPG although a preferred fuel, is not used because of inability of households in this category to afford the use of this particular fuel. The second choice is probably kerosene, and the third charcoal and lastly wood. However, lower

TABLE 4.3: Cooking Fuels Used in Urban Households

	Percent of households in group using				
	Fire-	Char-	Kero-	LPG	Electri-
Higher Income Group					
Kuala Lumpur	0	17	19	87	50
Bangkok	1	20	-	83	na
Manila	1	0	1	78	19
Hyderabad	13	neg.	57	71	na
Middle Income Group					
Kuala Lumpur	7	23	57	52	35
Bangkok	4	32	-	63	na
Manila	2	1	5	73	19
Hyderabad	24	neg.	65	54	na
Lower Income Group					
Kuala Lumpur	4	15	75	25	19
Bangkok	10.1	30	-	32	na
Manila	9	1	35	45	11
Hyderabad	41	neg.	70	19	na

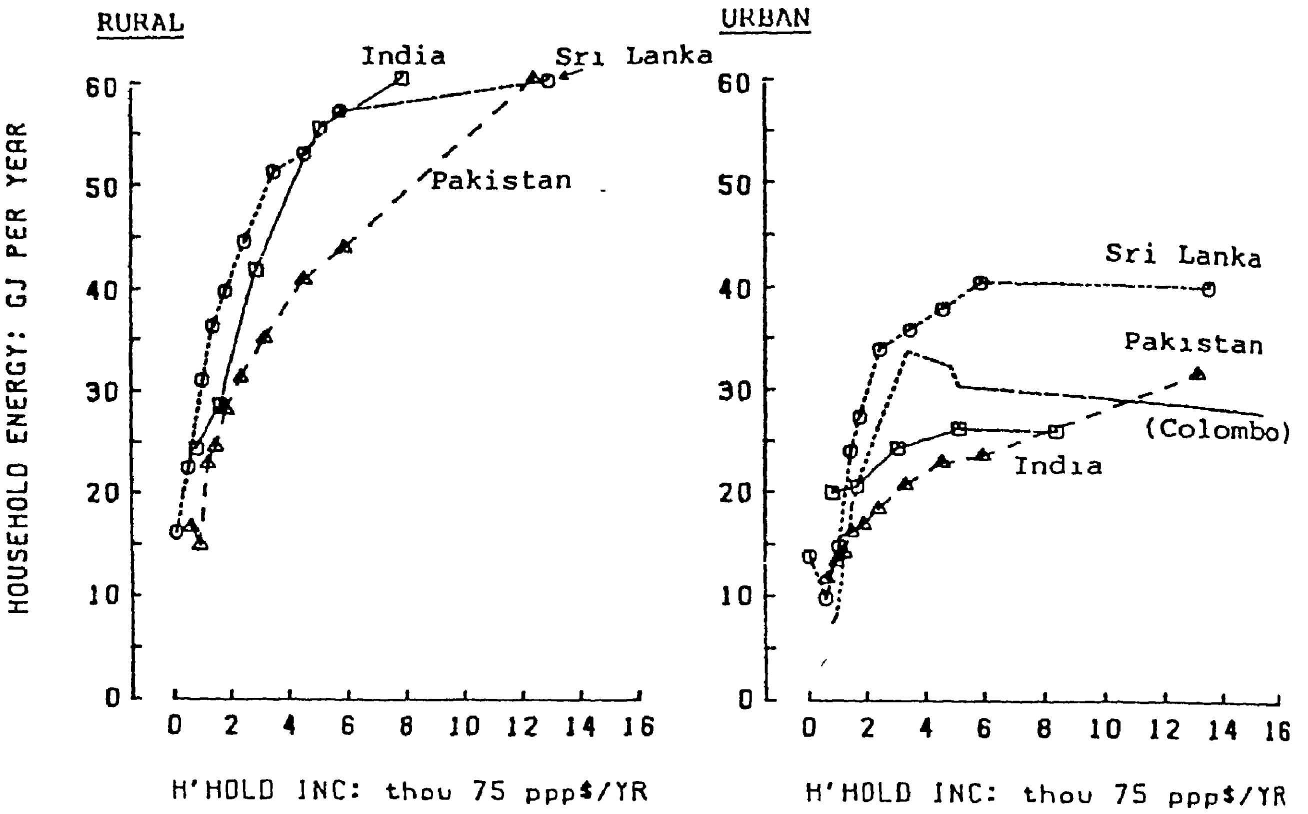


FIGURE 4.1: Household Energy by Household Income - 4 Asian Countries

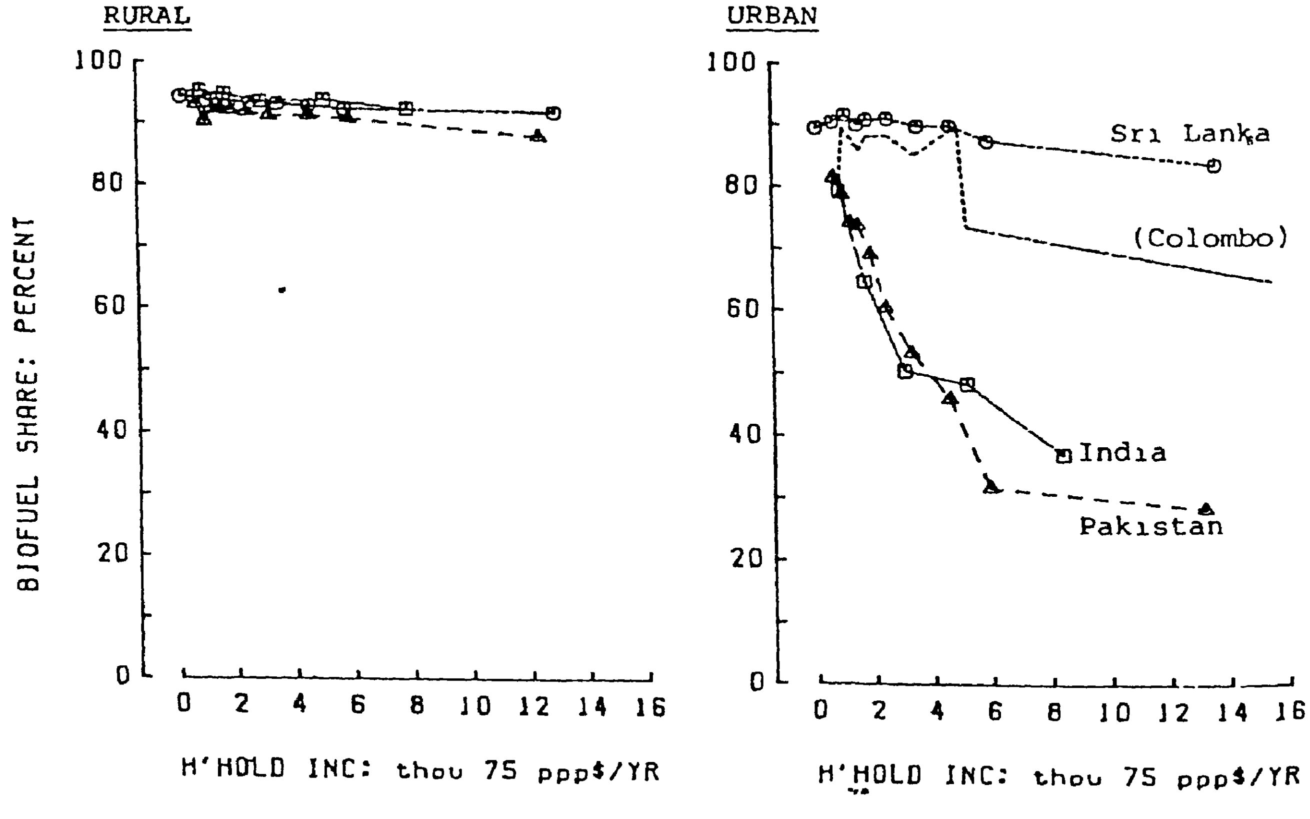


FIGURE 4.2: Biofuel Share by Household Income - 4 Asian Countries
PPP$: purchasing power parity dollar

income households choose kerosene, charcoal and wood depending upon their availability. For instance, in Kuala Lumpur, Manila, and Hyderabad where there is no limiting policy on kerosene, it is used by a majority of households in the lower income category. For the higher income category it is the second choice after LPG. After kerosene, the choice falls on wood and its derivative charcoal. Kerosene is predominantly the poor man's fuel in Kuala Lumpur, Manila and Hyderabad, although in Hyderabad a substantial number of higher income households are also observed to be using this fuel. In Thailand all kerosene is diverted towards rural areas for their domestic requirement and thus is not available to residents of Bangkok.

Hyderabad, which has a better supply system for wood than charcoal has higher percent of households using wood particularly in the lower income category. In Manila as well, reliance on wood is higher, as it is cheaper and more available than charcoal. Better supply of charcoal and lack of wood in Kuala Lumpur and Bangkok shifts the reliance on charcoal for fuel.

The supply and availability factors therefore play a key role in shaping energy consumption patterns, especially in the lower income category of households. At the higher income category of households also, it is very likely that the use of LPG is constrained by shortages and lack of access to LPG supplies. In a later section we shall analyse the constraints faced by households in Indian cities in using their prefered fuels.

4.5 SURVEYS IN INDIA

A study of urban household energy patterns in India proves be difficult, since there is no agency collecting data regarding this on a regular basis. The major studies on which we have based our macro level analysis are (i) The survey conducted by NCAER in 1977-'78 in about 8000 rural and 4000 urban households, results of which were published in 1985 and (ii) the consumption expenditure survey for 1983 conducted by the National Sample Survey Organisation (NSSO).

A few micro level studies have also been done(see Annex 1 for details). However, in view of the variations in coverage, methodology and focus in the different studies, comparisons between them become difficult. We have,in this study, attempted to put the data from these micro level surveys and the data from the survey conducted by TERI on a common framework to facilitate our analysis at the micro level.

4.6 THE URBAN - RURAL DIFFERENCE

We now turn to a macro level analysis of energy consumption patterns in Indian households. For this we have mostly relied on the NCAER Survey. Though this is now dated, it is the only comprehensive survey done on a national level. The NCAER has carried out a repeat survey later, but published data on this is not available. The NCAER study uses coal replacement units for aggregation. We have preferred to aggregate on the basis of energy content of various fuels. The conversion factors used for different fuels and efficiencies assumed for end use devices for arriving at 'useful' energy are given in Annex.2.

The kind of fuel used in Indian homes is strongly determined by whether they are in rural or urban areas. And, in urban homes, by income also. TABLE 4.4 gives the estimates of monthly per capita consumption of different fuels in rural and urban households in India for 1977-78 based on the NCAER study.

Urban areas use only 14 kgs of biofuels per capita as compared to 29 kgs per capita in rural areas, with households substituting commercial fuels like coke and kerosene, for crop and animal wastes.

Firewood, surprisingly, continues to play an important role in household energy, even in urban areas. It meets more than half of the total gross energy needs of urban homes (about the same as in rural areas!)

In terms of gross energy, the per capita energy consumption in rural areas is 32% higher, compared to that in urban areas. This is because of the predominant use of traditional biofuels(95% of total energy) in rural homes. As we know, such fuels have low efficiencies (10% in wood-burning chulhas compared to 60% in LPG stoves.)

TABLE 4.4: Urban-rural Differences in Energy Consumption

Fuel(units)	energy/capita monthly rural	urban	% in gross energy rural	urban	% in 'useful' energy rural	urban
Commercial						
Soft coke(Kg)	0.19	2.61	1.0	17.4	3.1	23.2
Kerosene(Lt)	0.43	0.97	3.3	10.1	2.6	21.1
L.P.G.(Kg)	neg	0.18	neg	2.5	neg	9.8
Elecy.(kWh)	0.41	2.92	0.3	3.0	0.4	1.9
			4.6	36.7	5.1	56.0
Biofuels						
Firewood(Kg)	13.17	9.73	54.4	53.6	59.2	35.5
Veg waste(Kg)	4.92	0.67	17.9	3.3	15.6	1.7
Dung cake(Kg)	11.08	3.00	23.1	8.4	20.1	4.5
Charcoal(Kg)	neg	0.30	neg	1.7	neg	2.3
			95.4	67.0	94.9	44.0
Gross(m.cal)	115.1	86.1				
'Useful'(m.cal)	10.6	13.0				

Source: NCAER (1985)

If we look at the consumption of 'useful' energy, taking into account conversion efficiencies, urban areas show 23% higher consumption per capita than rural areas. Firewood is still an important source meeting 35% of 'useful' energy in urban households.

In rural areas, there is no significant change in per capita firewood consumption, across income groups. Though consumption of total energy-both gross and 'useful' - increases with income, the percentage share of energy, met by biofuels, remains about the same. (TABLE 4.5).

The urban scenario is different. With increase in income, while the gross energy per capita declines, the 'useful' energy increases from 12.0 mcal per capita in the lowest income group to 15.7 mcal in the highest income group. We also note that in any income group the consumption in rural areas is higher compared to urban areas in gross energy terms, but in terms of 'useful' energy urban families use more energy per capita. Urban families often switch from biofuels to more efficient, convenient and cleaner modern fuels and equipments. This occurs, usually, in two steps--from biofuels to kerosene, and then to LPG.

TABLE 4.5: Per Capita Monthly Consumption of Major Fuels
By Income Groups : 1977-78

	Income Groups (Rs. per annum per household)					
	Upto 3000	3000-6000	6000-12000	12000-18000	18000+	All
RURAL						
Soft Coke(Kg)	0.12	0.14	0.47	0.54	0.79	0.19
Kerosene(Lt)	0.44	0.40	0.40	0.36	0.35	0.43
Electricity(Kwh)	0.20	0.46	0.83	1.28	1.44	0.41
Firewood(Kg)	13.67	12.33	13.75	14.33	12.92	13.17
Veg Waste(Kg)	5.08	4.33	5.33	6.92	6.17	4.92
Dung Cake(Kg)	10.50	11.25	12.00	13.75	15.50	11.08
Total Gross (m. cal)	116.27	108.54	123.50	137.58	133.41	115.10
Useful(m.cal)	10.67	9.93	11.49	12.73	12.45	10.58
URBAN						
Soft Coke(Kg)	1.55	2.52	3.83	2.80	2.70	2.61
Kerosene(Lt)	0.83	1.04	0.99	1.02	0.83	0.97
Electricity(Kwh)	1.01	2.43	4.33	6.56	9.00	2.92
L.P.G.(Kg)	neg.	0.09	0.32	0.78	0.93	0.18
Firewood(Kg)	13.89	9.66	6.83	5.68	4.61	9.73
Veg Waste(Kg)	0.92	0.52	0.58	1.28	0.50	0.67
Dung Cake(Kg)	3.22	2.94	2.87	3.50	1.87	3.00
Charcoal(kg)	0.27	0.31	0.39	0.22	0.23	0.30
Total Gross (m. cal)	99.16	83.68	82.17	81.96	71.32	86.10
Useful(m.cal)	12.01	12.32	14.21	16.18	15.73	12.98

The income level at which these switches occur is an important parameter for policy makers. The factors which will influence the transition are:

- * availability of modern fuel
- * prices of such fuels in relation to biofuels
- * the cost of suitable equipment
- * convenience of different fuels

At the lowest income group, there is no difference between rural and urban areas in per capita firewood consumption, but as income rises in urban areas, it declines from 13.8 kgs for the lowest income group, to 4.1 kgs for the highest income group.

The demand for electricity also increases steeply as income rises--the highest income group consuming per capita nine times as much as the lowest income group.

Alam, in his Hyderabad study, has done some regression analysis which indicates that a 10 per cent increase in income leads to

- 2.6% increase in useful energy
- 8% decrease in firewood consumption
- 9% increase in LPG use.

4.7 CHANGES IN FUEL MIX ACROSS INCOME GROUPS

It is interesting to compare the fuel mix in households in different income-groups. TABLE 4.6 gives these shares for rural and urban areas on the basis of 'useful' energy.

TABL 4.6: Fuel-Mix Across Income Groups (Percentage Share in terms of 'Useful' Energy)

	Income Groups (Rs. per annum per household)					
	Upto 3000	3000-6000	6000-12000	12000-18000	18000+	All
RURAL						
Softcoke	1.3	1.6	4.7	4.9	7.3	2.1
Kerosene	2.7	2.6	2.3	1.8	1.8	2.6
Electricity	0.2	0.4	0.6	0.9	1.0	0.4
Firewood	60.8	59.0	56.8	53.5	49.3	59.2
Veg. Waste	16.1	14.6	15.6	18.2	16.6	15.6
Dung Cake	18.9	21.8	20.0	20.7	24.0	20.1
URBAN						
Softcoke	14.9	23.6	31.1	20.0	19.8	23.2
Kerosene	19.4	23.8	19.6	17.7	14.8	21.1
Electricity	0.8	1.7	2.6	3.5	4.9	1.9
LPG	-	5.2	15.9	34.0	41.3	9.8
Firewood	54.9	37.3	22.8	16.7	13.9	35.5
Veg. Waste	2.6	1.4	1.4	2.7	1.1	1.7
Dung Cake	5.2	4.5	3.9	4.1	2.3	4.5
Charcoal	2.2	2.5	2.7	1.3	1.5	2.3

As far as rural areas are concerned there is no significant change in the fuel mix as income increases. The share of firewood does decline somewhat, with shares of crop waste and animal dung increasing (perhaps reflecting the fact that richer households in villages have more agricultural land and more cattle).

In urban areas one sees a substantial shift in fuel mix with the share of firewood declining from 54.9% to 13.9% as income rises. The shift in the first stage is to kerosene and soft coke and later to LPG, with LPG meeting 41.7% of 'useful' energy in the highest income group. (It must be pointed out that these figures pertain to 1977-78, when LPG supplies had not picked up. In a later section, where we use more recent studies we will see that the share of LPG is even higher, with firewood use in the higher income groups becoming negligible).

A comparison of fuel mix for the lowest income group in rural and urban areas shows that firewood continues to be a major source for this income group. The only difference is that since crop waste and dung are not readily available, these users shift to firewood. Families who may be using firewood shift to kerosene and soft coke.

4.8 ENERGY CONSUMPTION BY END USE

Bulk of the energy is used for cooking--84.3% of the total. Significantly, this share is only marginally lower than that in rural areas(89.7%). As income rises, the share of energy for cooking declines (TABLE 4.7). On the other hand, share of energy used for lighting and other purposes increases with increase in income.

Most of the poor households (81%) depend upon kerosene for lighting. As income rises, this proportion drops sharply, with a shift to electricity for lighting. Two thirds of the total households use electricity for lighting(as compared to one sixth in rural areas).

4.10 VARIATIONS ACROSS STATES

Aggregate patterns tend to hide the differences between one region and another. Looking at the Statewise urban household energy consumption figures in the NCAER study one sees that the per capita monthly consumption varies from 58 mcal (West Bengal) to 139 mcal (Himachal Pradesh). The States with high energy consumption (besides H.P.) are Orissa, Bihar, Madhya Pradesh and Kerala. Most other States consume 70-80 mcal per capita (TABLE 4.8).

Table 4.7: Energy Consumption by End Uses

Income Groups (Rs. per annum per household)	Upto 3000	3000-6000	6000-12000	12000-18000	18000+	All
1. Total Energy						
% Share						
Cooking	87.2	85.2	82.7	80.2	77.0	84.3
Lighting	7.2	8.3	8.6	9.0	10.2	8.3
Other Uses	5.6	6.7	8.7	10.6	12.8	7.4
2. Kerosene						
% Households using it for--						
Cooking	23.6	45.6	59.7	64.0	67.7	43.1
Lighting	80.9	57.8	38.8	29.4	22.8	59.0
% Share in lighting	44.5	20.0	11.2	6.5	6.1	22.3
3. Electricity						
% households using it for--						
lighting	31.8	67.9	90.9	95.5	97.6	63.4
% share in lighting	85.6	76.9	63.3	54.8	46.5	67.5

TABLE 4.8: Per Capita Monthly Consumption of Energy in Different States of India 1977-78

States	Monthly per Capita Consumption ('000 Kcal)		Percentage Share of Commercial Fuels	
	Rural	Urban	Rural	Urban
1. Northern Region				
Uttar Pradesh	116.5	70.4	2.6	18.6
Rajasthan	108.9	78.7	2.2	24.2
Punjab	117.9	88.7	4.3	28.1
Haryana	98.2	81.5	3.9	43.2
Himachal Pradesh	183.9	138.6	3.3	21.7
Jammu & Kashmir	143.9	85.7	3.8	19.6
2. Eastern Region				
West Bengal	127.6	57.9	13.4	64.3
Bihar	127.3	99.0	4.5	56.9
Orissa	97.3	121.1	3.6	7.6
Assam	104.8	77.0	6.1	38.4
3. Southern Region				
Andhra Pradesh	99.2	86.3	5.2	23.1
Karnataka	102.6	84.4	4.2	16.6
Kerala	87.6	103.7	5.7	6.8
Tamil Nadu	90.3	86.6	6.0	17.0
4. Western Region				
Gujarat	84.2	68.5	13.2	46.1
Maharashtra	89.8	68.5	10.0	48.6
Madhya Pradesh	119.0	98.8	2.9	33.0

As is to be expected commercial energy consumption is higher in urban areas as compared to rural areas. But here again there are large regional variations, with Kerala and Orissa at one end (where commercial energy forms only 6-7% of the total) and West Bengal at the other end (where the share of commercial energy is 64%). In the states where there is relatively high proportion of commercial energy - West Bengal, Bihar, Maharashtra, Gujarat, Haryana and Assam - soft coke forms a significant proportion of total household energy.

In Gujarat and Maharashtra, kerosene is an important fuel next to firewood. Kersoene is also an important fuel in the urban areas of Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, Rajasthan, Punjab and J&K. Among the biofuels, firewood is the major fuel in the urban areas of all states except in West Bengal and Bihar (where soft coke is an important fuel) and in Punjab and Haryana (where dung and crop residues are more readily available).

4.10 VARIATION ACROSS URBAN SIZE

Accessability to modern fuels strongly affects the switch to such fuels. Usually, the larger the urban settlement the more developed the distribution and marketing systems for LPG and kerosene. Further, when such commercial fuels are in short supply the large cities often get a more favourable treatment in allotment. At the same time in smaller settlements biofuels may be more readily available. Problems relating to space for storage in larger cities may also be a deterrent factor for the use of biofuels. Thus urban size could have effect on fuel choice (TABLE 4.9).

We see that the shares of kerosene and LPG, the main biomass alternatives, increase rapidly with urban size. Share of biofuels in 'useful' energy terms decrease from around 60 per cent to 25% as the size of settlement increases.

Table 4.9: Household Energy Patterns and City Size
India 1979

Population (in 1000s)	Percentage of shares of fuels					
	Elec.	Kerosene	LPG	Coke	Firewood	Other Biofuels
Over 500	13.5	28.9	15.6	17.3	17.7	7.4
200-500	9.4	28.6	13.0	14.2	20.7	14.4
100-200	9.2	19.8	7.2	21.3	29.6	12.9
50-100	8.0	18.7	6.4	22.5	31.8	12.6
20-50	6.3	9.5	2.9	18.8	38.6	23.9
Under 20	6.7	16.6	1.5	14.3	32.9	28.2

Source: NCAER (1985)

4.11 FUEL TRANSITION OVER TIME

Normally it is difficult to study trends over time since repeat surveys for the same region are not carried out. Fortunately, in India, in 1983-84 NCAER conducted a nationwide urban household energy survey comparable to their earlier one made in 1978-89. Preliminary results are available from this study to give us an idea of the change in fuel mix between 1979 and 1984. This five year period is particularly important since during this time LPG and kerosene supplies were stepped up, and prices of these fuels became lower compared to firewood. As was to be expected large changes in the fuel mix in urban households occured in this five year period (TABLE 4.10).

The data reveals the following trends:

- a substantial switch away from firewood took place mostly to kerosene, but also to LPG;
- drop in firewood shares occured in every income group, though for the lowest income group it was least, and progressively higher for the higher income groups;
- share of soft coke became smaller across all income groups;
- shares of kerosene and LPG almost doubled and by 1984 were meeting nearly one half of total urban household energy requirements;

TABLE 4.10: Fuel Shares for Cooking and Heating by Income: India, 1978-79 and 1981-82

		Income Groups (Rs. per annum per household)					
		Upto 3000	3000-6000	6000-12000	12000-18000	18000+	All
Firewood	1979	60.0	40.9	25.1	17.4	12.1	42.4
	1984	53.5	30.8	17.9	9.9	9.6	27.4
Soft Coke	1979	12.8	20.2	23.6	16.7	17.3	18.4
	1984	6.4	18.0	17.9	15.2	8.3	15.3
Kerosene	1979	13.2	21.3	21.5	22.0	18.9	18.7
	1984	23.8	36.9	40.2	38.2	32.8	35.7
LPG	1979	0.8	4.6	14.2	26.9	32.9	6.6
	1984	1.2	4.6	15.7	27.9	39.3	11.5
Other	1979	13.3	13.1	15.6	17.0	18.8	13.9
	1984	15.2	9.7	8.3	8.8	10.1	10.1
(Thousand Households)	1979	(7286)	(9895)	(4792)	(611)	(524)	(23108)
	1984	(4885)	(9298)	(9742)	(2598)	(1193)	(27716)

Shares are on a coal replacement basis for cooking and heating.
Source: Leach 1986, page 76.

- importance of kerosene increased across all income groups;
- LPG, on the other hand, continued to be confined to the higher income groups;
- there was a shift in the distribution of urban households across income groups with increase in shares of the middle to high income groups and reduction in the share of the lowest income group.

The State-wise data which is shown in FIGURE 4.3 indicates also that there was significant reduction in the use of firewood in some States. Increase in kerosene and LPG shares can be seen in all the States. Soft coke lost its importance as a household fuel except in West Bengal and Maharashtra which is in the major coal belt. Substantial variations in consumption patterns among States continued.

This analysis underscores the need for carrying out national household energy surveys in urban areas on a periodical basis to enable energy planners to assess the energy transition that is taking place. In the absence of such data it is well nigh impossible to make long term projections of household energy use in urban areas and to guide the production, supply and use of household fuels in an optimal manner.

4.12 HOUSEHOLD PREFERENCES AND BARRIERS TO FUEL SUBSTITUTION:

Households often are not in a position to use the fuel of their choice. In India the results of two studies are available which have tried to find the reasons why households use a particular fuel and not the preferred alternative. The two studies are i) the survey conducted by NCAER in 1977-78, at the macro level and ii) the survey conducted in Hyderabad, by B. Bowonder et.al. at the micro level.

The NCAER data (TABLE 4.11) revealed that the proportion of households using kerosene, which was not their first choice is alarmingly high, being 72%. More than 40% users of soft coke and firewood were also not using these fuels out of choice. Only in the case of LPG, majority of the users (more than 95%) were using it out of preference. A large number of households are unable to use their preferred fuel for cooking.

TABLE 4.11: Preference Pattern Among Users

Fuel Uses	Percentage of households using a fuel but did not prefer it
Soft Coke	45.7
Kerosene	72.2
LPG	2.6
Dung Cake	95.0
Vegetable and Crop Waste	89.5
Firewood and Twigs	41.3

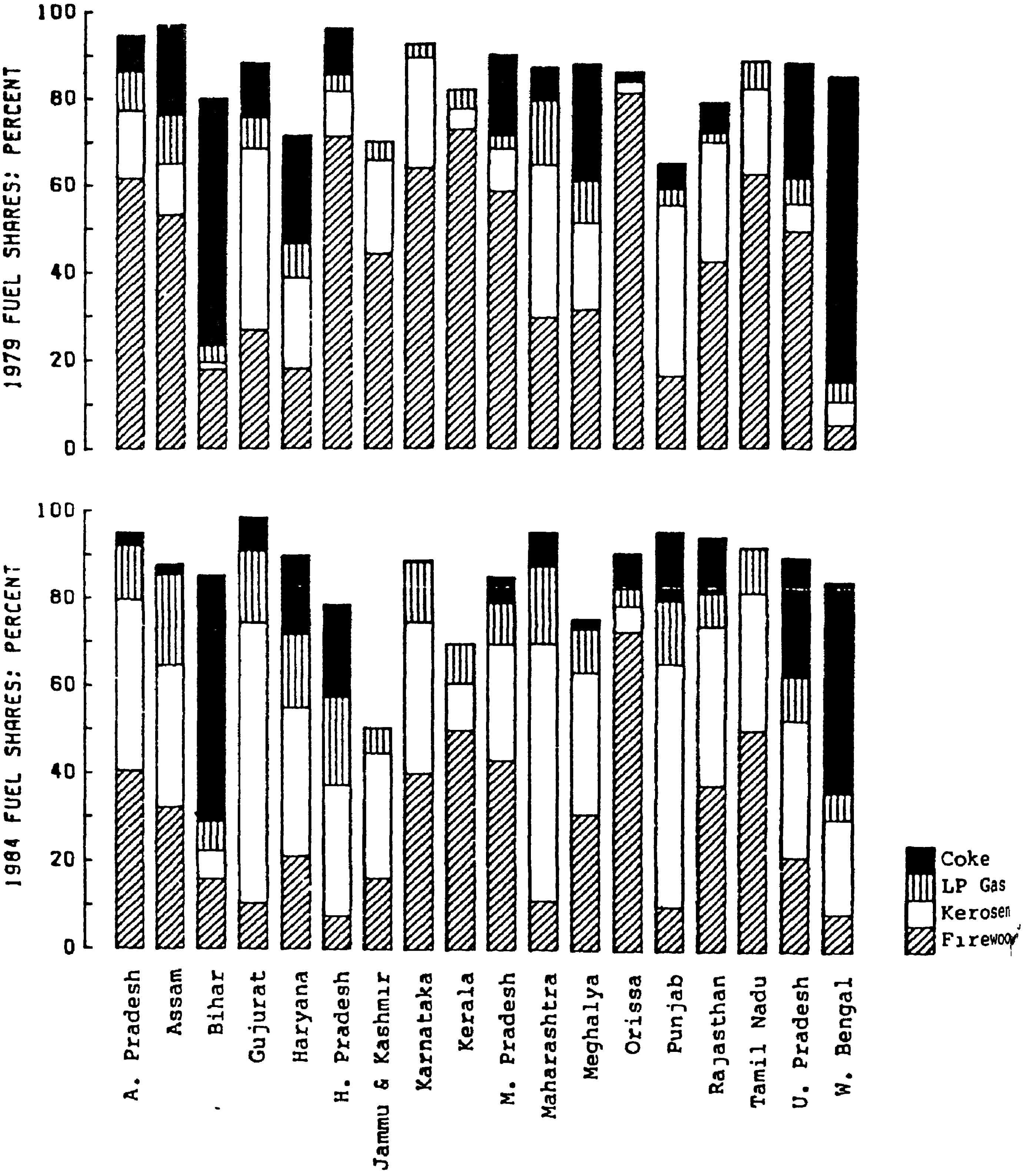


FIGURE 4.3: Urban Household Energy for Cooking and Heating by State: 1979 (upper) and 1984 (lower)
Source: Leach 1986 page 77.

TABLE 4.12 reveals that of the total households in urban areas not using their preferred fuels, 78.5% indicated preference for LPG. Percent of households preferring kerosene and softcoke were 7.7 and 6.6 respectively. Clearly the first choice of a fuel for cooking is LPG followed by kerosene and softcoke. This indicates that convenience, cleanliness and efficiency of a fuel dictates preference. But for various reasons (TABLE 4.13) families are not in a position to use the preferred fuel.

The reason for not using LPG had a strong relationship with household income. As household income increased price did not appear to be a constraint, while the constraint on availability was more commonly reported. Even among the lower income households, a significant proportion of the households preferring LPG reported non-availability as the major bottleneck. Of the total households preferring kerosene as a fuel, many do not use it because of the high cost. Unlike LPG, more than availability, affordability was the limiting factor for the use of kerosene. Not only do households in lower income category find kerosene a costly fuel, but so also households in the higher income bracket.

It should be mentioned here that theoretically the price of kerosene is subsidised but due to inefficiencies and malpractices in the public distribution system kerosene has often to be purchased in the open market system at prices which are substantially higher than the 'official' price.

TABLE 4.12: Cooking Fuel Preferred by Households not Using Their Preferred Fuel

Fuel Preferred	Percent of Households
LPG	78.5
Kerosene	7.7
Soft Coke	6.6
Firewood and Twigs	2.3
Others	4.4

TABLE 4.13: Reasons for not using a fuel

Annual Income Group (Rs.)	LPG			Kerosene		
	Costly	Not easily available	Others	Costly	Not easily available	Others
Upto 3000	27.31	70.25	2.45	66.12	33.88	-
3000 - 6000	23.36	73.28	3.37	68.63	31.47	-
6001 - 12000	11.14	81.04	7.82	72.81	25.33	1.85
12001 - 18000	9.60	84.08	6.32	65.10	24.13	10.76
Over 18000	6.15	91.76	2.09	100.00	-	-

TABLE 4.14 provides an interesting insight into the nature of the change in the pattern of fuel used in a five year period. Almost 50% of the households reporting shift to other fuels were using firewood five years back while 26% of the households were earlier using softcoke. Almost 50% of these firewood users shifted to softcoke and 18% each to LPG and kerosene. About 23% of softcoke users had also changed their cooking fuel. Around 66% of households previously using softcoke shifted to LPG for their cooking fuel and 18% reported shifts to kerosene. A majority of kerosene users reported switching over to LPG.

This confirms the expected trend that households are shifting to modern forms of fuel. Electricity is still not a common fuel for cooking. Further, there are clearly two steps involved in the transition from traditional fuels to better fuels. Firewood is considered an inferior fuel and its consumption falls as income rise. Firewood users generally shift to softcoke and kerosene with increase in income. As income increases further, kerosene and softcoke give way to LPG.

In the study conducted by Bowonder - for the Hyderabad city, one of the aspects covered was, reasons why households do not use kerosene and instead use firewood. In the lowest income group, almost 65 percent of households found kerosene to be an expensive fuel, while 20 percent of households gave inavailability as a barrier for switching. Many households continued to use firewood on account of habit or for safety considerations. In the next higher income group availability - either from the government's kerosene quota at the subsidized price or from the open market - was reported to be insufficient to meet their cooking energy demand.

The above analysis basically indicates the following:

a) There is a transition toward modern fuel as income increases;

b) This transition is driven by 'non-economic' preferences like convenience of use and storage, security of supply and efficiency of use;

TABLE 4.14: Change in Fuel Used

Fuel Used	Fuel Used 5 Years Back					
	Soft-coke	Kero-sene	Char-coal	Fire-wood	LPG	Others
Soft coke	14.65	-	-	74.36	-	10.99
Kerosene	24.05	-	5.15	51.15	15.87	3.78
Charcoal	-	-	-	96.06	..	3.94
Firewood	13.75	4.67	23.20	23.20	17.57	18.12
LPG	45.40	26.46	1.25	26.90	-	-
Total	26.57	10.88	3.09	47.01	4.04	

c) However, there are barriers to this transition which are mainly:

- Availability of the preferred fuel;
- Affordability both in terms of 'one time' payments for equipments and connection costs as also monthly payments for fuel supplies;
- relative prices of fuels;

We will now look at the results of some recent studies done at the city/town level to supplement the findings at the macro level.

4.13 ANALYSIS OF CITY LEVEL STUDIES

In this section we put together the information from some micro level studies of urban household energy. The studies included are:

i) The survey of 10 Indian cities/towns carried out by the Tata Energy Research Institute in 1987 - Of these 10 towns/cities only five are taken up for analysis viz. Delhi, Madras, Jaipur, Jabalpur and Shahibabad.

ii) The survey of 8 Maharashtra towns - Pune, Ahmednagar, Junnar, Talegaon, Srirampur, Satara, Nanded and Sholapur (Nair and Krishnayya, 1985).

iii) The survey in Hyderbad (Alam et.al. 1985a)

iv) The survey in Raipur (Macaulay, 1987).

TABLE 4.15: Household Energy Consumption in Selected Cities

	Population '000	'Useful' Annual Energy Cons. per capita('000 kcal)	Electricity kWh
Delhi	5729	284.6	612.0
Madras	4289	271.6	340.0
Hyderabad	2546	186.0*	NA
Pune	1685	240.8	129.6
Raipur	338	214.8*	NA
Jaipur	1015	241.3	330.0
Jabalpur	757	258.6	256.0
A.Nagar	181	202.2	103.2
Sahibabad	NA	285.6	225.0
Junnar	18	260.9	68.4
Talegaon	22	196.0	62.4
Srirampur	55	201.1	110.4
Satara	84	220.2	117.6
Nanded	191	188.3	98.4
Solapur	514	191.6	147.6

* Excludes electricity consumption.

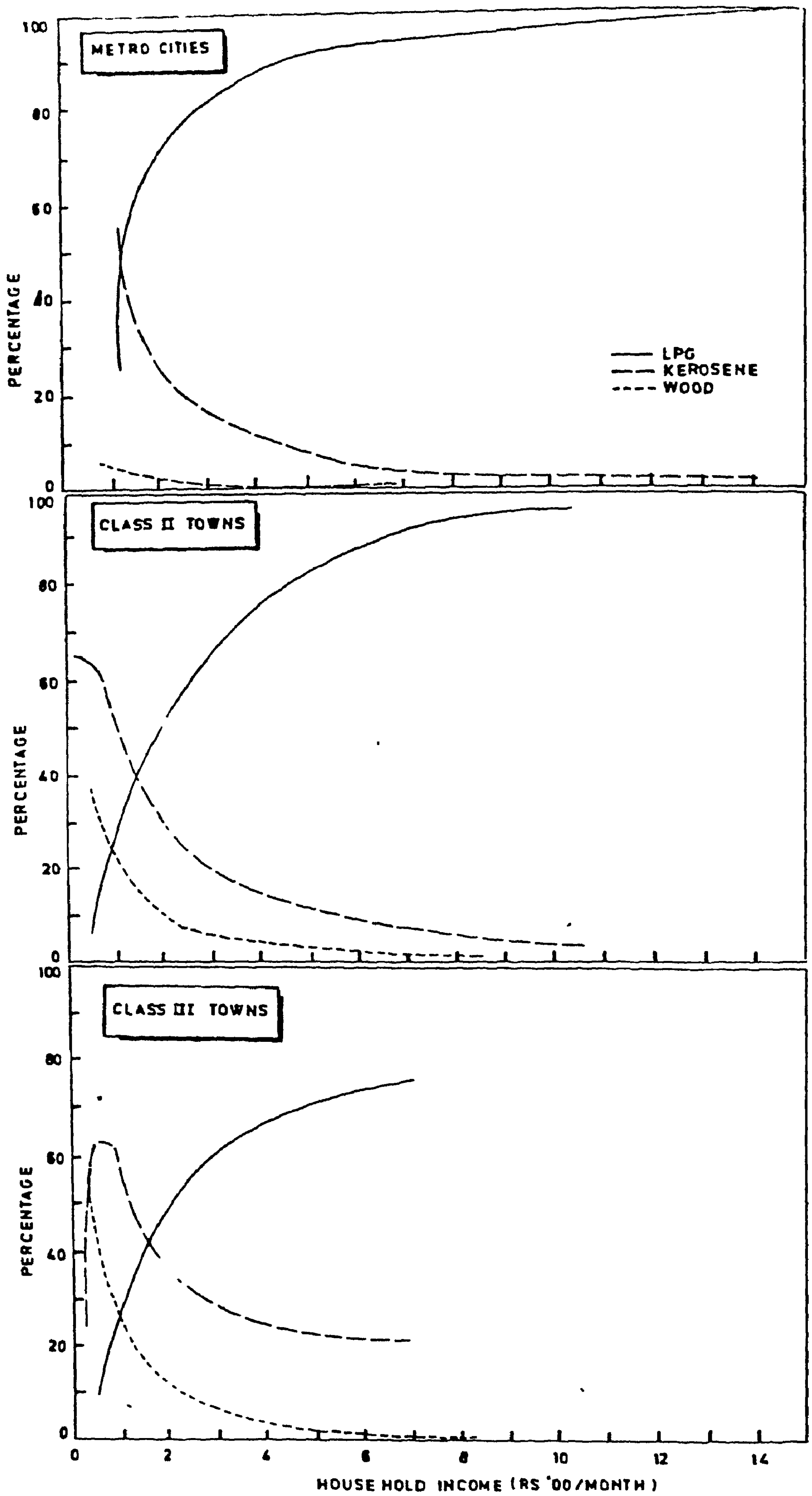


FIGURE 4.4:
Fuel Mix Transition
Across Income Groups

The data in these surveys have been brought to a common framework using the conversion ratios spelt out in Annex. II. The data obtained from the microlevel studies is given in Annex. III.

The aggregate average per capita consumption figures are given in TABLE 4.15. One sees a variation from 188 mcal in Nanded to 285 mcal in Delhi and its satellite town, Sahihababad. Variation in electricity consumption is more striking. A metro city like Delhi consumes 612 kWh per capita - nearly ten times the level in a small town like Junnar.

What about the fuel mix across various income groups? The results of our analysis are summarised in FIGURES 4.4 to 4.6. The groupings of cities has been done keeping in mind the supply position and resource availability. The four groups of cities are:

I : 2 Metro cities - Delhi and Madras - where accessability to modern fuels is very good.

II : 5 Class II Cities - Jaipur, Sahibabad, Pune, Jabalpur and Ahmedanagar - where accessability to modern fuels is moderate

III : 6 Class III towns - Junnar, Talegaon, Srirampur, Satara, Nanded and Sholapur - where there are difficulties in getting supplies of kerosene and LPG.

IV : Hyderabad and Raipur - which appear to have greater access to biofuel supplies.

FIGURE 4.4 which shows the fuel shares across income groups reveals a similar income - transition of fuel mix in the different groups of cities. The main income band in which the transition is taking place is the income group upto Rs. 300 per month per household, where kerosene is replacing wood and LPG is replacing kerosene. Beyond a household income of Rs. 500 per month the shift as income increases is very gradual. If one has to understand the dynamics of this transition more clearly more detailed studies are required focussing on these lower income groups.

The fuel usage in different class cities is brought out in FIGURE 4.5. One can clearly see for the same income groups LPG share is higher for the higher class cities. The share of LPG in the highest income group is only 70% in Class III towns.

Kerosene share, on the other hand shows the reverse with kerosene shares in Class III towns being highest. Class II towns fall in between Class III and Metro. An interesting feature in the kerosene curve is the sharp drop in the very low income range in class III towns. Presumably this is because in this income groups kerosene is used only as a lighting fuel and not for cooking.

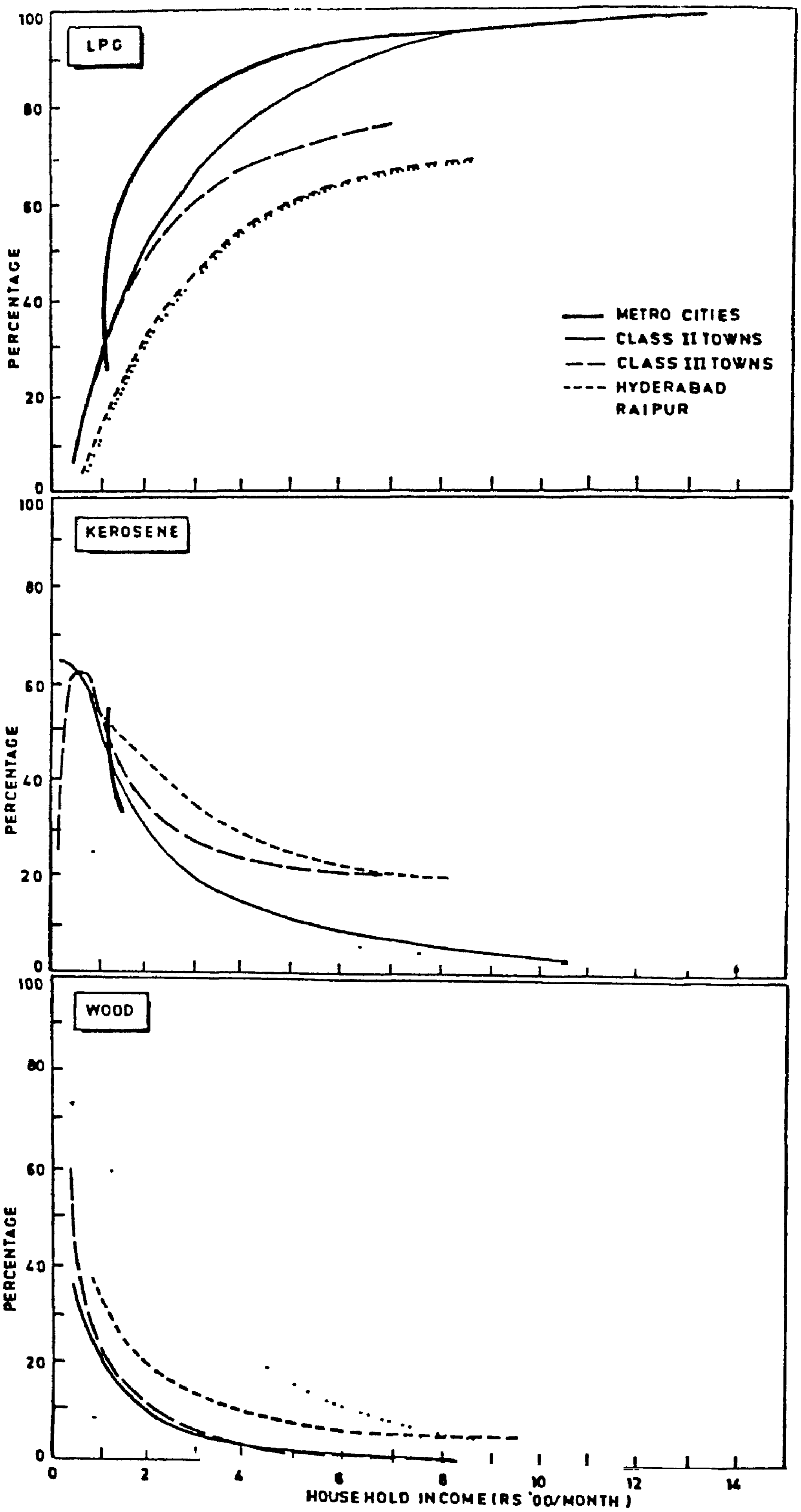


FIGURE 4.5:
Shares of different fuels across Income Groups

The use of wood in Metro cities is very low across all income groups. But in class III towns wood meets 60% of 'useful' energy in the lowest income groups. Even in Class II towns, use of wood, use of wood for cooking is fairly high in the very lowest income groups.

Hyderabad and Raipur appear to fall in a totally different pattern (FIGURE 4.6). These towns have greater dependence on wood and less on LPG. In fact, even in the highest group, the LPG share in these two cities is only 60%. Among the two cities Raipur is more dependent on wood than Hyderabad. Perhaps this is because both these cities are located in States which have a good forest cover.

Accessability to modern fuels and availability of biomass fuels in the hinterland of the cities thus appears to be an important determinant in the fuel choice of households.

The micro level studies do confirm the findings in the macro level studies. But one sees that considerable variations in consumption patterns can take place from city to city - governed more by supply factors than household preferences. There is a need to take up more detailed studies relating to supply constraints and biomass resource availability. Such studies have to be done across a large number of cities if we are to fully understand the energy transition taking place in urban households. Energy Planners would need such data if they have to ensure supply of energy to urban households in an optimum manner.

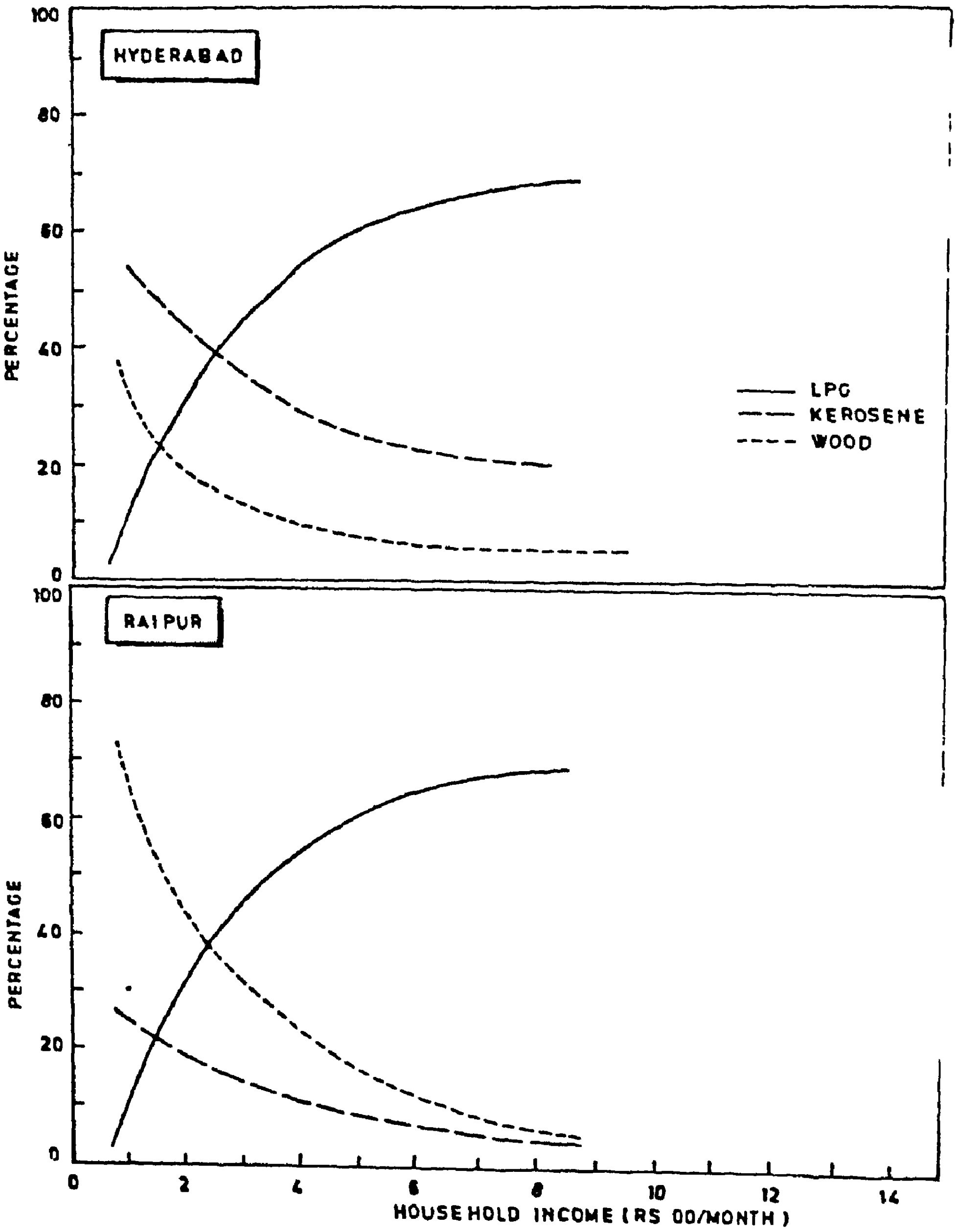


FIGURE 4.6: Fuel Mix Pattern in Hyderabad and Raipur

4.14 USE OF ELECTRICITY

The contrast in per capita consumption level of electricity in developing and developed countries was clearly brought out in TABLE 4.1. Richer countries among the developing countries were also observed to have higher per capita electricity use in comparison to poorer countries.

Ownership levels of electric appliances in cities of various countries are shown in TABLE 4.16. It appears that fans, television, refrigerator and radio are one of the first electrical appliances acquired when urban families have sufficient money. Of these appliances refrigerators are electricity intensive

Air-conditioners and water heaters are the other major energy intensive electric appliances. However, their use is at present rather limited in developing countries. Also, it should be noted that the use of these two appliances, to a large extent, would be influenced by the climatic of a region/country or a city.

Comparing the per capita consumption of electricity in rural and urban areas of India, one sees that electricity use in urban areas is seven times higher than in rural areas. The higher use of electrical appliance primarily is a result of higher household income and modernization. We have seen in the earlier sections that there is a moderate positive correlation between the level of urbanisation and per capita income of a country. The increase in household income leads to demand for new services such as refrigeration, entertainment, air conditioning etc. which have a major impact on domestic demand for electricity.

The survey done by TERI in 6 cities has gathered information on ownership of electricity using appliances in different income groups. The data is presented in Annex IV. The cities are arranged in order of size.

Table 4.16: Electric Appliance Ownership in Urban Areas

	Radio	T.V.	Fan	Washer	Iron	Cooker	Refrigerator	Air-cond.	Water Heater
	(Per cent of households)								
China	39	66	45	2	1	-	< 1	-	-
Liberia	76	4	56	1	74	-	52	7	-
Guatemala	78	25	-	-	-	16	12	-	-
Manila	80	78	82	-	94	44	63	5	-
Malaysia	70	79	75	16	77	91	70	9	12
Hong Kong	90	91	96	34	87	84	80	13	9
Bangkok		96	-	5	-	89	82	15	4
Taipei	-	92	94	53	-		85	12	6
India									

Among the energy intensive activities refrigeration is almost universal in richer families of the larger cities. Air-conditioning is uncommon except in wealthy households. Use of geysers for water heating again is prevalent only in the higher income groups. Average number of fans and lights (incandescent bulbs and tube lights) used by richer families is about three times higher compared to the poorer families - obviously reflection of the larger dewlling sizes of richer families. We see that the average number of black and white colour television sets owned is higher in poorer families while colour television sets is more common in the higher income group.

Again, to some extent the switch-over from use of immersion rod to geysers is evident among the highest and second highest income categories. The influence of life style on the demand for a particular appliance is evident.

4.15 FUELWOOD USE IN URBAN AREAS

We have already seen that fuelwood meets a large share of gross energy consumption in urban households particularly that of the poor. Of the total fuelwood consumption it is estimated that nearly one-third is used in urban areas. The urban consumption of fuelwood is of particular concern since it is more in the form of logs and may have a greater impact on deforestation than rural consumption. A clearer understanding of fuelwood markets is necessary to better plan programmes for fuelwood plantations.

In India studies have been done in two urban centres - Hyderabad and Bangalore - which focus on urban fuelwood usage and supply (Alam et al 1985 and Reddy 1983). Some interesting and disconcerting facts are revealed in these studies.

The Hyderabad study shows the following:

- The amount of fuelwood used in the city is 178,000 tonnes per year;
- Only 6% of the supply comes from registered government forests. The rest is from private forests and lands and illegal cuttings in government forests;
- The predominant portion of the trade is in the hands of private contractors and retailers;
- Firewood supplies come from long distances - even from as far as 280 kms. The average distance of transportation is 88 km;
- A major portion of the supply is moved by diesel based trucks;
- About 85% of the total fuelwood consumption is in the household sector;

- Fuelwood is the major form of cooking fuels in poor households accounting for 40 % of cooking energy;
- As income rises fuelwood use drops. A 10% increase in household income leads to 7% decline in fuelwood use;

The conclusions in the Bangalore study are similar:

- The annual supply of fuelwood to the city is 440,000 tonnes;
- Most of the retail trade (95%) is in the private sector with no control exercised by the government;
- The fuelwood is moved from as far as 700 kms. The average distance moved is around 160 kms.
- 85% of the transportation is done by trucks. The annual usage of diesel for this purpose is 2.2 million litres involving a foreign exchange outgo of Rs. 3.5 million per year;
- Households account for about 78% of the total fuelwood consumption. Of the fuelwood 53% is used for water heating and 42% for cooking;
- Over 80% of total household fuelwood consumption is by households with income of less than Rs. 200 per month;
- About 10 hectares of forests have to be cleared per day to sustain fuelwood supplies to the city.

The situation is indeed alarming. However, one must add that both Hyderabad and Bangalore are located in states with good forest resources and these studies may not reflect the situation in other cities. Even so the situation warrants serious attention of energy planners and environmentalists.

Rising fuelwood prices are no doubt a sure sign of increasing shortages and scarcity. In India, between 1979 and 1986 the real price of fuelwood rose by 50% - which was not as steep an increase as in Sri Lanka or in some countries in Africa. The study by Bowonder et.al. (1985) attempted to relate urban firewood prices to forest resources. Using satellite imagery data of 1974-75 and 1980-82, the study estimated the per capita forests area in a 30,000 sq.km. circle around 40 Indian cities.

FIGURE 4.7 presents some key results from the study as brought out by Leach (1986). One notes a clear (though somewhat weak) correlation between 1984 firewood price in each centre and the per capita area of forest resources around it. As the latter decreases by about 50,000 firewood prices increase five-fold. There is also a clear association between urban size, price and forest resources - larger cities have higher firewood prices and per capita forest area. But the study does not clearly show whether the rise in fuelwood

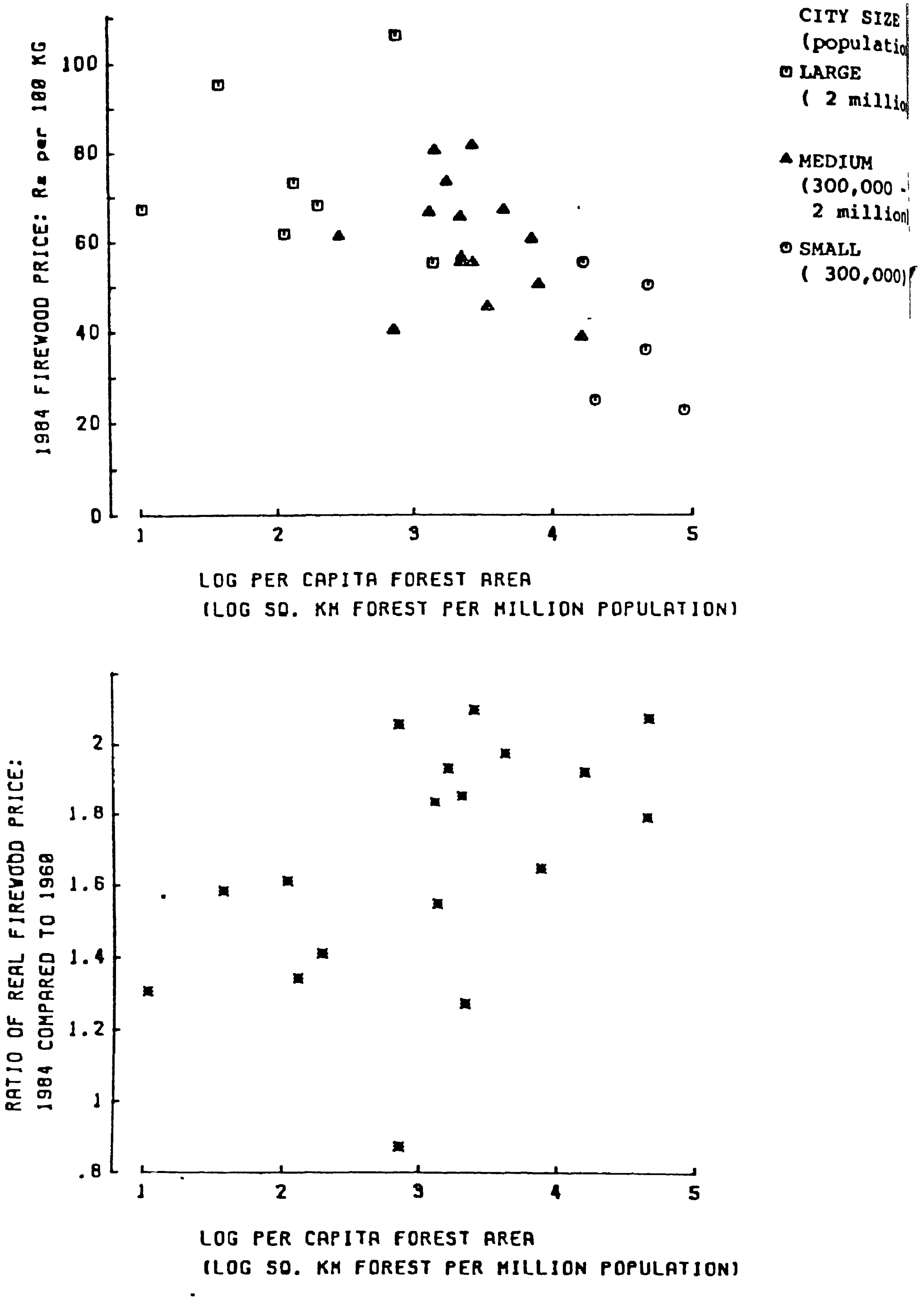


FIGURE 4.7: Urban Firewood Prices Compared with Forest Area
Source: Leach (1986), pg. 56

prices has been caused by deforestation, or whether it is due to the market structure in the urban centres. Further, there is no clear indication whether deforestation has been caused by urban fuelwood demand or by other factors relating to urbanisation itself.

When talking of firewood we must distinguish firewood logs from lower grade fuels such as branches, twigs and brushwood. This distinction is crucial, in terms of the impact of wood fuel demand on tree resources. Supply of logs involves felling of trees. Small branches and twigs, however, can be gathered without depleting tree resources.

Rural homes commonly use twigs. The greatest use of logs is by the urban sector, particularly by the urban poor (TABLE 9.18).

Also, more firewood is bought (and not collected) in urban areas. So, we need to establish proper supply and trade networks to meet their firewood demand.

Firewood production and trade is mostly in private hands. Government has no control over the prices at which these traders sell their firewood, and the urban poor are at the mercy of traders. Alam et.al. (1985) has provided the following cost structure in regard to fuelwood prices in Hyderabad.

As can be seen there is a wide gap between selling price at the production centre and the actual price paid by the consumer. But we have no clear idea of profit margins of the various stages of the trade. More detailed studies of the urban fuelwood trade are needed if Government is to plan for some form of control on firewood trade to make this fuel available at reasonable prices to the urban poor.

		Costs	Profit Margins
1.	Production Costs	(?)	(?)
2.	Selling price at Warangal Forest Circle	61.3	
3.	Transport Cost & Margin	85.5	
4.	Wholesale Buying Price	146.8	
5.	Wholesale Cost & Margin	91.2	(?)
6.	Retailer Buying Price	230.0	
7.	Retailers Costs	42.9	
8.	Retailers Margins	66.1	
9.	Retail Price	347	
10.	Average Consumer Price (according to household survey)	454	
11.	Unexplained gap	107	(?)

Table 4.18: Firewood Supply Matrix

	Rural			Urban		
	Logs	Twigs	Total	Logs	Twigs	Total
% of Firewood consumption	25.5	74.5	100.0	73.2	26.8	100.0
% purchased	42.8	5.7	15.1	96.5	61.9	87.3

Nearly a third of the total fuelwood is currently used in urban areas. Since urban consumption consists of logs, it may contribute to deforestation in the hinterland of these cities. The study done by Bowonder (1985), estimates that the areas of closed forest within a 100 km radius of nine of India's principal cities fell sharply in the last decade or so (TABLE 4.19). The loss ranged from 15% around Coimbatore, to as much as 60% decline around Delhi. How much of this loss is on account of the fuelwood demand is not clear, but it does point to the need for immediate concern.

As forests recede, firewood has to be hauled from interior areas. In Hyderabad and Bangalore for example, we have seen, that the average distance over which firewood is being hauled, to supply these cities, is 100 and 200 kms. respectively. Truck transport, a highly energy-intensive mode, accounts for 85 to 94% of the total firewood movement. Clearly firewood trade in cities will have important economic and environmental impacts on areas far distant from the cities.

Energy and urban planners will therefore have to pay much closer attention to the fuelwood needs of urban areas and plan for the required supply systematically to avoid further environmental degradation of the hinter land.

4.16 POTENTIAL FOR ENERGY FROM CITY WASTES

Municipal solid waste can meet a portion of the urban needs if tapped efficiently. The average amount of garbage generated by a city dweller in India in 400 grams per day (Vimal and Tyagi, 1984). Though this is low in comparison to one kg. in Japan and about 2 kg. in USA, the total quantity of this waste expected is substantial (TABLE 4.20). The compostable portion of this is estimated to be 40%.

Table 4.19 : Changes in Closed Forest Cover Around Major Cities in India

CITY	FOREST COVER(in sq km.)		CHANGE %
	1972-75	1980-82	
Bangalore	3853	2762	-28
Bombay	5649	3672	-35
Calcutta	55	41	-25
Coimbatore	5525	4700	-15
Delhi	254	101	-60
Hyderabad	40	26	-35
Jaipur	1534	786	-49
Madras	918	568	-38
Nagpur	3116	2051	-34

To assess the energy potential from these wastes one requires the physical and chemical characteristics of the waste. Unfortunately, few local authorities carry out a regular analysis of their city wastes and authentic information is not available. However, on the basis of some sample studies, Vimal and Tyagi (1984) have arrived at some average figures regarding the characteristics of the waste' (TABLE 4.21. One notes that there is no significant variation across city size, except in the largest size city (about 2 million) where the percentage of paper and organic matter is higher and the percentage of ash and earth is lower. The calorific value of the waste also increases as city size increases. It is desirable therefore that waste energy conversion systems should be first implemented in the metropolitan cities.

Incineration of these wastes may not be a viable option in view of the low calorific value and high moisture content. Modern incinerators have also a high cost. Incineration can be considered only for recovery of energy from USW of higher income residential areas or from predominantly industrial and commercial areas where the calorific value may be around 1500 kcal/kg. [A survey Bombay shows that calorific value can range from 900 kcal/kg to 4300 kcal/kg from area to area].

Another possible route is gas from landfills as is being done in the cities of some developed countries. But this calls for careful management of these landfills in order to avoid contamination of underground water. High costs are also involved for the heavy equipment needed to cover the wastes with soil.

The best option for recovering energy from urban wastes in India appears to be the anaerobic digestion route using biogas digestors. On the basis of the average physical and chemical characteristics it is estimated that the total biogas potential from city waste by the year 2000 could be 4.8 billion cubic metres of gas per year.

In addition to city garbage, we can also utilise the city sewage for energy recovery. At an estimate of waste discharge of 180 lpcd the total sewage discharge will be around 33 billion litres/day by the year 2000. It has been estimated that the biogas that can be generated from this city sewage by the year 2000 would be around 1.6 billion cubic metres of biogas.

This means that biogas from city wastes and sewage, if fully utilised, can meet 75% of the cooking energy needs of the lowest income group households (poorest 20% of the population) in urban areas.

Proper utilisation of city wastes to produce biogas for meeting the needs of the poor particularly could reduce the pressure on firewood demand. Detailed technical and economic studies have to be taken up in developing countries to develop appropriate waste recovery systems and examine its feasibility. Urban planners also should plan urban wastes and sewage disposal systems in conjunction with energy recovery systems.

TABLE 4.20: Potential Availability of City Garbage

Year	Population (million)	City Garbage (Million tonnes/year)		
		Total	Compostable	Non-compostable
1970-71	109.1	15.9	6.4	9.5
1980-81	159.7	23.3	9.3	14.0
2000-01	326.0	47.6	19.0	28.6

TABLE 4.21 : Characteristics of Urban Wastes in India

	Population Range (in millions)			
Physical characteristics (% by wt.)	< 0.2	0.2-0.5	0.5-2.0	> 2.0
Paper	3.1	4.8	3.8	7.1
Rubber and Leather	0.5	0.6	0.6	0.9
Plastic	0.6	0.6	0.8	0.8
Metals	0.5	0.4	0.6	1.0
Glass	0.3	0.3	0.4	0.8
Ash and Earth	46.6	40.0	41.8	31.7
Purtrescibles	33.4	39.8	40.2	41.7
Calorific value (Kcal/kg)	801	874	867	1140
Chemical Characteristics				
Moisture	22.1	25.1	22.5	31.2
pH	8.2	8.2	8.3	7.7
Organic Matter	22.0	22.5	21.5	27.6
Carbon	12.3	12.5	11.9	15.3
Nitrogen	0.6	0.6	0.6	0.6
Phosphorous	0.7	0.7	0.7	0.6
Potash	0.7	0.7	0.7	0.7
C/N Ratio	20.4	20.5	21.4	26.2

All values given on dry weight % basis except moisture, pH and C/N ratio.

Source: Vimal and Tyagi (1984) Tables 30 and 31.

4.17 EXPENDITURE ON ENERGY

The latest data on expenditure on energy was provided by the 1983 quiquennial consumer expenditure survey of NSSO. This shows that the average per capita monthly expenditure on energy in urban areas (Rs. 11.4) is 40% higher than the corresponding expenditure in rural areas. However, the share of energy expenditure to total is about the same in rural and urban areas. Though expenditure have risen over the years, the pattern mentioned above has not changed much (See TABLE 4.22). However, the share of energy expenditures in total expenditure rose both in rural and urban areas. This was because energy prices rose at a faster rate than prices of food and other consumer articles.

As is to be expected the expenditure on energy rises as total expenditure rises, but the share of energy expenditure in the total expenditure shows an opposite trend. (TABLE 4.23).

4.18 PRICES OF HOUSEHOLD FUELS : EQUITY AND EFFICIENCY ISSUES

One factor that may influence fuel switch is the price of a fuel compared to its alternative. In India, kerosene and LPG, the main commercial household fuels are subsidised. On the other hand there is no government control on firewood, which is the main biofuel in urban areas.

The trend of energy prices between 1979 and 1986 (TABLE 4.24 shows that the highest increase (160%) was registered by firewood, an important fuel for the urban poor. This was followed by soft coke (141%). The price of LPG and kerosene rose much less sharply. In fact the real price of kerosene declined over this period by 11%, while LPG price moved along with consumers price index. Although the pit head price of soft coke is controlled by government and was not increased, the retail price rose steeply since there is no control over transport costs and trade margins. Thus energy price increases had a more adverse impact on the lower income groups dependent on firewood and soft coke.

TABLE 4.22: Per Capita Monthly Consumer Expenditure on Energy from NSSO Surveys

	Rural				Urban			
	1983	77-78	72-73	67-68	1983	77-78	72-73	67-68
Expenditure on Fuel & light(Rs)	7.92	4.13	2.49	1.88	11.36	6.17	3.57	2.56
As % of Non-Food Expenditure	20.5	16.8	20.7	24.8	16.9	16.0	15.9	17.1
As % of Total Expenditure	7.0	6.0	5.6	5.6	6.9	6.4	5.6	5.7

TABLE 4.23: Monthly Per Capita Expenditure on Energy According to Per Capita Total Expenditure Classes (1983)

Per Capita Monthly Consumer Expenditure Classes	Per Capita Monthly Expenditure on Energy		Expenditure on Energy %age to total Consumer Expenditure		Percentage to Total Non-food Expenditure	
	Rural	Urban	Rural	Urban	Rural	Urban
0 - 30	3.37	2.63	13.6	12.0	57.6	36.8
30 - 40	4.03	4.05	11.2	11.3	50.9	45.6
40 - 50	4.68	4.88	10.3	10.7	45.6	42.5
50 - 60	5.36	5.67	9.7	10.2	40.6	39.8
60 - 70	5.98	6.44	9.2	9.9	37.4	37.1
70 - 85	6.70	7.22	8.7	9.3	33.8	34.1
85 - 100	7.32	8.19	7.9	8.8	29.0	30.4
100 - 125	8.32	9.44	7.5	8.4	24.9	26.8
125 - 150	9.41	10.79	6.9	7.9	20.3	23.4
150 - 200	10.50	12.57	6.1	7.3	16.1	19.3
200 - 250	12.11	14.82	5.5	6.7	12.8	15.9
250 - 300	13.39	16.22	4.9	5.9	10.2	13.0
300 +	16.80	21.45	3.8	4.7	6.8	8.7
All	7.92	11.36	7.0	6.9	20.5	16.9

TABLE 4.24 : Indices of Retail Prices of Household Fuels (June 1979 = 100)

	Firewood	Softcoke	Kerosene	LPG	Consumer Price Index
June 1981	131 (104)	141 (113)	113 (90)	130 (104)	125
June 1982	175 (130)	163 (121)	124 (92)	145 (107)	135
June 1983	173 (114)	192 (126)	129 (85)	136 (90)	152
June 1985	232 (143)	217 (134)	149 (92)	155 (96)	162
June 1986	260 (151)	241 (140)	154 (89)	174 (101)	172

Source: Bhatia (1988)
Figures in brackets indicate increase in price index relative to CPI Index.

If we analyse the prices of different fuels with reference to the useful energy delivered we find that the plight of the urban poor was even worse (TABLE 4.25 for lighting, the urban poor, who use kerosene, pay nearly five times more for equivalent energy output than the rich, who use electricity.

In cooking fuels, LPG turns out to be the cheapest. The price changes from 1979 have worked against the interest of the poor. In 1979 firewood was costing (in useful energy terms) about the same as kerosene and slightly higher than LPG. Soft coke was the cheapest fuel. But by 1986 firewood was nearly twice the equivalent cost of LPG and more than 50% costlier than kerosene. This was due to the control exercised on LPG and kerosene prices by government and subsidies given for these fuels. Soft coke, which was earlier cheaper than LPG, had become more expensive. This brought about a massive shift to LPG and kerosene (as explained in Section 4.11). But the lowest income group, who could not afford to invest in LPG and kerosene equivalent or for whom these fuels were not available was adversely affected by the increase in fuelwood prices.

One objective of energy pricing is to promote efficiency. This means the price of the fuel should reflect the true economic opportunity costs. A recent analysis (Bhatia 1988) shows that the shadow price of commercial household fuels was much below the market price as follows:

Fuel	Unit	Shadow Price (Rs.)	Market Price	Market Price as % of shadow price
Kerosene	Litre	4.5	2.25	50
LPG	kg.	6.75	4.06	60
Electricity	kWh	1.50	0.52	356

TABLE 4.25: Comparative Costs of Providing Useful Energy

Fuel	Unit	Gross Energy kcal/unit	Efficiecy of Use	Quantity Required for 100 M Cal of useful energy	Market Price of Fuel (Rs./unit)		Cost of providing 100 cal of useful energy by each fuel	
					June 1979	June 1986	June 1979	June 1986
Lighting								
Electricity	kWh	860	10	1163	0.26	0.50	302.4	581.5
Kerosene	Litre	8950	1	1117	1.46	2.25	1630.8	2513.3
Cooking								
LPG	kg.	11750	60	14	2.33	4.06	32.6	56.8
Kerosene	Litre	8950	40	28	1.46	2.25	40.9	63.0
Softcoke	kg.	5770	20	87	0.28	0.68	24.4	59.2
Charcoal	kg.	5000	25	80	1.01	3.00	80.8	240.8
Electricity	kWh	860	80	145	0.26	0.50	37.7	72.5
Firewood	kg.	4750	10	210	0.19	0.48	39.9	100.8

Thus, there were significant subsidies available to consumers of kerosene, LPG and electricity, but the element of subsidy in softcoke was relatively small. There was no subsidy available on firewood. While the subsidy on kerosene could be justified on equity considerations - since they were used by the poor for cooking and partly for lighting - there was no justification for subsidising LPG, the cooking fuel of the urban middle and higher income groups. There was also no justification for the subsidy on electricity. Equity considerations should have warranted a greater control on fuelwood prices and greater investments to increase fuelwood production.

What were the other effects of these deviations of market prices from efficiency prices? The subsidy on kerosene relative to soft coke led to a shift from soft coke to kerosene. In June 1979, the cost of using softcoke was only 60% of the corresponding cost of using kerosene and 75% that of LPG. But by June 1986 effective cost of using softcoke was only 6% lower than that of using kerosene. LPG had become marginally cheaper than softcoke.

Further, while the retail price of softcoke was not controlled, the pithead price was controlled and fixed at Rs. 175 per tonne - far below the actual production cost of Rs. 292 - leaving no incentive for the producer to step up supply. There was also no incentive to modernise plants to improve the quality of softcoke or to put up new low temperature carbonisation units. The net effect was a reduction in consumption of softcoke from 3.25 million tonnes to 1.5 million tonnes by 1986-87. Bhatia (1988) computes that this shift implied increased imports of 1.56 million tonnes of kerosene in the period 1977 to 1982 resulting in a foreign exchange outgo of $ 450 million.

A second effect of the subsidy on kerosene was a diversion of kerosene for uses other than cooking and lighting. The Advisory Board on Energy estimated that in 1982-83, 13.5% of the total kerosene consumption was used for adulteration with diesel - resulting in a net outgo of $ 17 million in foreign exchange.

Low energy prices of kerosene and electricity also acted as a constraint in adoption of energy conservation in cooking and lighting. Similarly, the consumers' willingness to adopt new devices based on renewable energy has also been adversely affected on account of the subsidised prices.

4.19 ENERGY USE BY THE URBAN POOR

The problems faced by urban poor households must be paid special attention since they are in the worst position in regard to the quantity and quality of fuels as also the cost of obtaining these supplies.

The energy consumption of the poor households is between 300 and 500 K cal per capita per day of 'useful' energy. This is much lower than the minimum requirements of 680 K cal, worked out by the Advisory Board on Energy. In particular, the consumption of energy for lighting is very low since a majority of them use kerosene lamps.

Even in urban areas, poor households are heavily dependent on biofuels. However, unlike in rural areas, where most of the fuel required is gathered by the poor, the poor in urban areas have to purchase the biofuel required. These fuels are burnt in low-efficiency devices. Hence, the cost, per unit of useful energy, is more than that of the commercial fuel used by the rich. In the Maharashtra study (Nair and Krishnayya 1985) for example, it is seen that even after capitalising the initial cost of investment the energy cost for the rich is only about half that for the poor (For lighting 7.5 as against 15.5 and for cooking 0.75 instead of Rs 1.1 for 1000 k.cal.)

Added to this is the problem that these fuels are smoky and lead to eye and lung disorders among the poor. Women are particularly affected.

The poor are increasingly facing difficulty in obtaining adequate amounts of biofuels. But they do not have an alternative. The supply of kerosene is inadequate, particularly in the small towns. There is, no doubt, a public distribution system in the cities. But in one survey done recently 44% of households in urban areas reported that the kerosene supplies by ration shops was inadequate. A large portion of the poor, who live in unauthorised slums, do not benefit from this distribution system, since they are unable to get ration cards. The NCAER study (1985) showed that of the total kerosene used for cooking in urban areas only 16% is used by the lowest income group. Hence the urban poor are not able to get their share of benefits from subsidised kerosene supplies.

The poor cannot dream of an LPG connection because the initial investment required towards deposit and connection charges, and towards cost of equipment, is much beyond their reach.

They cannot use electricity for lighting purposes, again because of the high initial cost towards wiring and obtaining connection. Many of them may be living in unauthorised slums where electricity will not be extended by the Electricity Board.

The problem of scarcity has been aggravated by the steep rise in fuel prices. The prices of energy products have increased at a faster rate than the general price level. In particular, the price of firewood has increased steeply (nearly fourfold between 1983 and 1985). The poor are particularly hit because energy forms a larger portion of their budget.

We have seen that nearly 37% of total non-food expenditure goes towards energy(in the lowest-expenditure class) as compared to 9% in the highest-expenditure class.

In order to give relief to energy consumers commercial fuels like kerosene, coal, electricity are being subsidised. In actual practice, though the subsidy is available to all income classes, often the urban poor do not get ration cards and are forced to buy the kerosene in the market. An evaluation of the essential supplies programme done recently indicated that 40% of the households purchased kerosene in the black market, paying 40 to 65 % more than the official price. Supplies of another convenient fuel(soft coke) used by the poor have declined by over 50%, over the last few years, because the pricing policy of government has not given remunerative prices to the producers.

The uncoordinated pricing and supply policies of Government has thus led to undue hardships for the urban poor. Energy planners need to pay particular attention to these inequity issues.

CHAPTER 5

ENERGY IN URBAN TRANSPORT

5.1 URBAN TRANSPORT SCENE IN INDIA

With the growth in urban population in India cities are expanding. With the growth of the city economic activities tend to get concentrated in a single centre or a couple of centres with residential areas spilling over to the suburbs. This has intensified commuter demand and increased trip lengths.

Road based transport modes play a vital role in the urban transport system in India. In most major urban centres these modes will continue to form the predominant transport system in the foreseeable future. Since these road based systems are dependent on oil, which is being imported in the country, it becomes important for urban and energy planners to plan for greater efficiency of energy use in urban transport to enable reduction in the import bill.

Unfortunately the present supply of public transport has been inadequate and of poor quality. This has led to the growth of personalized vehicles, with consequent problems of congestion, high costs, higher energy consumption and heavy atmospheric pollution. Traffic speeds are also falling leading to increased energy consumption. The effect of inadequacy of public transport can be clearly seen in the following sections where we proceed to analyse traffic data in urban India.

5.2 VEHICLE GROWTH AND COMPOSITION

There has been an exponential growth in motorised vehicles - with an average growth rate of nearly 13 percent per annum in the last decade (TABLE 5.1). The growth of two-wheelers has been very high (16.6%). The number of cars has also been growing at a higher rate (6.9%) than buses (5.7%) clearly indicating the shift from public transport to personalised transport. There has been a drastic change in vehicle composition in the last three decades FIGURE 5.1).

TABLE 5.1: Growth and Composition of Vehicles 1951-87

Year	Two Wheeler	Cars, Jeeps & Taxis	Buses	Trucks	Other Vehicles	Total
		('000 vehicles)				
1950-51	27	159	34	82	4	306
1960-61	88	310	57	168	42	665
1970-71	576	682	94	343	170	1865
1980-81	2528	1117	154	527	847	5173
1986-87	6749	1731	246	902	1417	11045
Annual Growth Rate Between						
50-51 & 60-61	12.5	6.9	5.3	7.4	26.5	8.1
60-61 & 70-71	20.7	8.2	5.1	7.4	15.0	10.9
70-71 & 80-81	15.9	5.1	5.1	4.4	17.4	10.7
76-77 & 86-87	16.9	7.0	7.5	8.9	11.8	13.0
50-51 & 86-87	16.6	6.9	5.7	5.9	17.7	10.5

Source: CMIE "Basic Statistics Relating to the Indian Economy" Vol.1, Aug 1988.

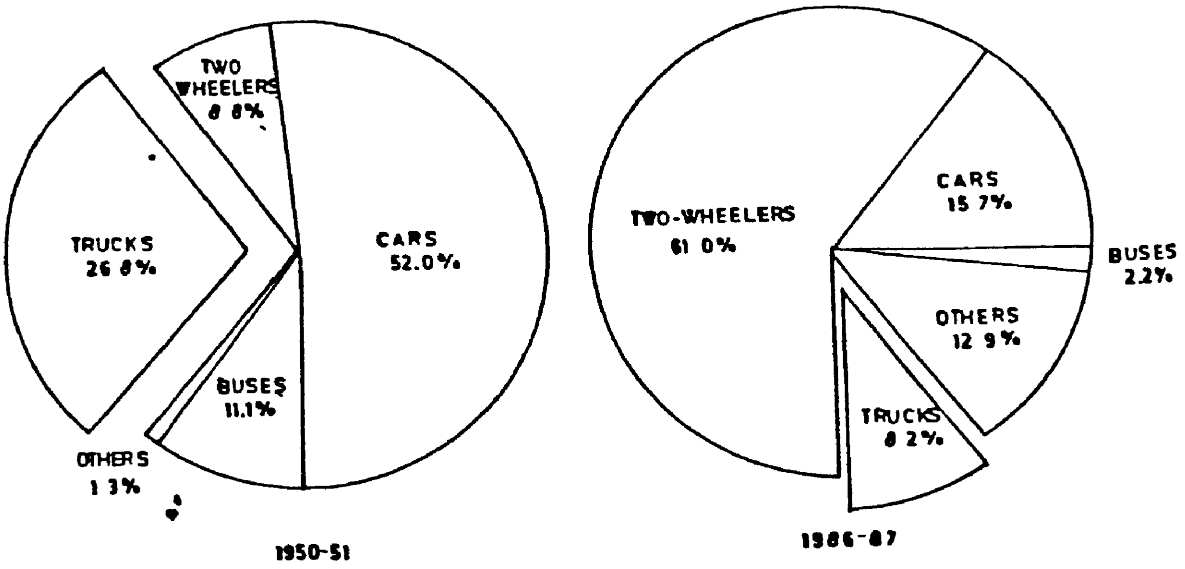


FIGURE 5.1: Changing Composition of Vehicles

The two wheeler has become the most popular mode of personal urban transport. If this trend continues congestion on roads will increase and traffic speeds will reduce, particularly for public transport buses, resulting in decreasing energy efficiency.

A forecast made by Central Institute of Road Transport shows that by the year 2000 two-wheelers will account for 82% of the total number of 42.4 million vehicles (TABLE 5.2).

The 12 metropolitan cities which account for only 6 per cent of the country's population, account for 40 per cent of the vehicles - 40 per cent of two wheelers, 50 per cent of the three wheelers, 50 per cent of cars and 25 per cent of buses in the country.The growth of vehicles from 1977 to 1985 has been around 11.5 per cent per annum (TABLE 5.3).

TABLE 5.2: Estimated Vehicle Population 1990 and 2000

	Vehicles in lakhs		Share %	
	1990	2000	1990	2000
Buses	2.8	5.5	2.1	1.3
Cars/Jeeps/Taxis	19.1	33.1	14.3	7.8
Two wheelers	96.1	346.5	72.0	81.1
Three wheelers	4.7	17.2	3.5	4.1
Trucks & others	10.8	21.3	8.1	5.0
Total	133.5	423.6	100.0	100.0

Source: CIRT (1988) Table 4.

TABLE 5.3: Vehicle Growth and Composition in Metropolitan Cities

	Vehicle Strength ('000)		% Growth	Vehicles* per million population	Vehicle Composition %					
	1977	1985			2 wh	3 wh	car	taxi	Bus	Other
Calcutta	147	286	95	259	30	-	47	4	2	17
Bombay	245	432	76	438	36	5	42	7	1	9
Delhi	389	841	116	1224	69	4	19	1	1	6
Madras	69	139	31	270	59	4	26	1	2	8
Bangalore	109	279	156	795	68	4	19	1	2	6
Hyderabad	na	172	na	564	77	5	11	-	1	6
Ahmedabad	68	177	160	580	68	13	13	-	2	4
Kanpur	32	89	178	452	60	2	8	1	3	27
Pune	106	265	150	792	71	7	10	1	1	10
Nagpur	na	83	na	532	71	3	13	-	1	12
Lucknow	27	82	204	678	74	2	14	1	1	8
Jaipur	34	127	274	1040	62	3	14	1	4	16

* Including trucks.
Source: Motor Transport Statistics, Ministry of Surface Transport.

The composition of vehicles in these cities shows that personalized vehicles account for 83 per cent of the vehicles while public transport buses are only 2 per cent of the total vehicles. In the over 4 million cities cars have a larger share (31 per cent) while in the other cities 2-wheelers are predominant (70 per cent).

The vehicle population per million population in these cities is much higher than the average of 76 for the country as a whole, revealing the high concentration of vehicles in these cities. Primary attention therefore needs to be paid for energy efficient transport systems in these 12 cities.

From the point of view of energy efficiency a rail based system would be best. Unfortunately only 3 cities viz Calcutta, Bombay and Madras have a suburban rail system. The total traffic on these systems is around 44 billion passenger kms. with an average trip length of 23 kms. This is forecast to increase to 106 BP km by the year 2000.

The present industrial policy of Government in regard to transportation equipment has been lopsided with more emphasis having been given for production of cars and two-wheelers rather than for cycles and buses (TABLE 5.4). In the last 6 years car and 2 wheeler production rose at over 20% per annum whereas the growth rate in bus production was only about 3%.

TABLE 5.4: Annual Production of Vehicles 1951-1987

	Annual Production of vehicles ('000)					Compound Growth Rate % Between			
	1951	61	71	81	87	51 & 61	61 & 71	71 & 81	81 & 87
Buses & Trucks	8.6	28.4	40.8	87.3	105.8	12.7	3.7	7.9	3.3
Cars	12.4	21.7	39.2	42.4	148.5	5.8	6.1	0.8	23.2
Jeeps	2.9	7.1	11.0	19.3	32.4	9.3	4.5	5.8	9.0
Scooters	-	15.3	68.7	201.4	625.7	-	16.2	11.3	20.8
Motorcycles	-	9.1	44.1	110.5	300.7	-	17.0	9.6	18.2
Mopeds	-	0.5	14.1	187.0	475.6	-	44.9	29.3	16.8
Bicycles (x 100)	1.1	10.5	18.3	49.9	65.4	25.2	5.7	10.6	4.6

Source: CMIE August 1988

JOURNEY SPEEDS

One of the critical factors affecting energy efficiency in urban transport is journey speed. The limited data available (TABLES 5.5 & 5.6) gives an idea of the low prevailing traffic speed in Indian cities as well as the reduction in speed over time. The speeds quoted are for cars; journey speeds of other vehicles will be even lower. The main points that come out are:

- overall journey speeds in large cities are 20-25 kph and in smaller cities 15-30 kph
- within central areas the journey speeds are critically low, ranging from 5-12 kph
- speeds are reducing generally inspite of road improvement programmes
- reduction in the share of slow moving vehicles increases the journey speeds

The effect of journey speed on the fuel consumption for different categories of vehicles is shown in FIGURE 5.2. It will be seen that the drop in journey speeds particularly effect the energy efficiency of buses, three wheelers and two wheelers. For example, in the case of buses a drop in journey speeds from 30 kph to 15 kph results in an increase of fuel consumption by 40-50 per cent. In many cities the average speed of public transport buses is below 15 kph. The establishment of exclusive busways in at least the major anterial roads would help in increasing these journeys speeds and reduce fuel consumption.

TABLE 5.5: Absolute Values of Journey Speeds in Certain Cities

City	Arterials (1986)	Central Area
Bombay	25-40	15-20
Delhi	25-40	10-15
Ahmedabad	15-25	5-7
Cochin	20-30	10-12
Madurai	25-35	10-12
Lucknow	20-25	5-12

Source: CRRI Studies

TABLE 5.6: Reduction in Journey Speeds Over Time

Road		Speed (Kph) 1962	1979	% age Increase
BOMBAY				
Netaji Subhash Road		56	40	- 42.9
Purandare Marg		48	27	- 43.8
Annie Besant Road		48	31	- 35.4
M.G.Road		40	25	- 37.5
Jamshedji Road		32	16	- 50.6
S.Bhagat Singh Road		32	27	- 15.6
P.D. Mellow Road		24	18	- 25.0
Nath Pai Road		32	20	- 37.5
DELHI				
Aurobindo Road		31	40	+ 29.0
Sardar Patel Road		40	45	+ 12.5
Patel Road		32	27	- 15.6
New Rohtak Road		26	25	- 3.8
Sham Nath Marg		41	44	+ 7.3
Netaji Subhash Road		28	22	- 21.4
Minto Road		23	24	+ 4.3
Panchkuian Road		24	22	- 8.3
Janpath		24	22	- 8.3
Dr. Zakir Hussain Marg		34	30	- 11.8
CALCUTTA				
Corridor	Route	1963	1981	
North-South	3	17	14	- 16.0
South-West	5	18	13	- 26.5
South-West	6	16	13	- 21.2
South-East	14	17	12	- 26.4
East-West	35A	17	11	- 34.7

Source: 1. Planning of Road System for Bombay Metropolitan Region, Vol. II-CRRI

2. Traffic Congestion on Selected Arterial Roads in Delhi - A Review - CRRI

3. CIRT (1988)

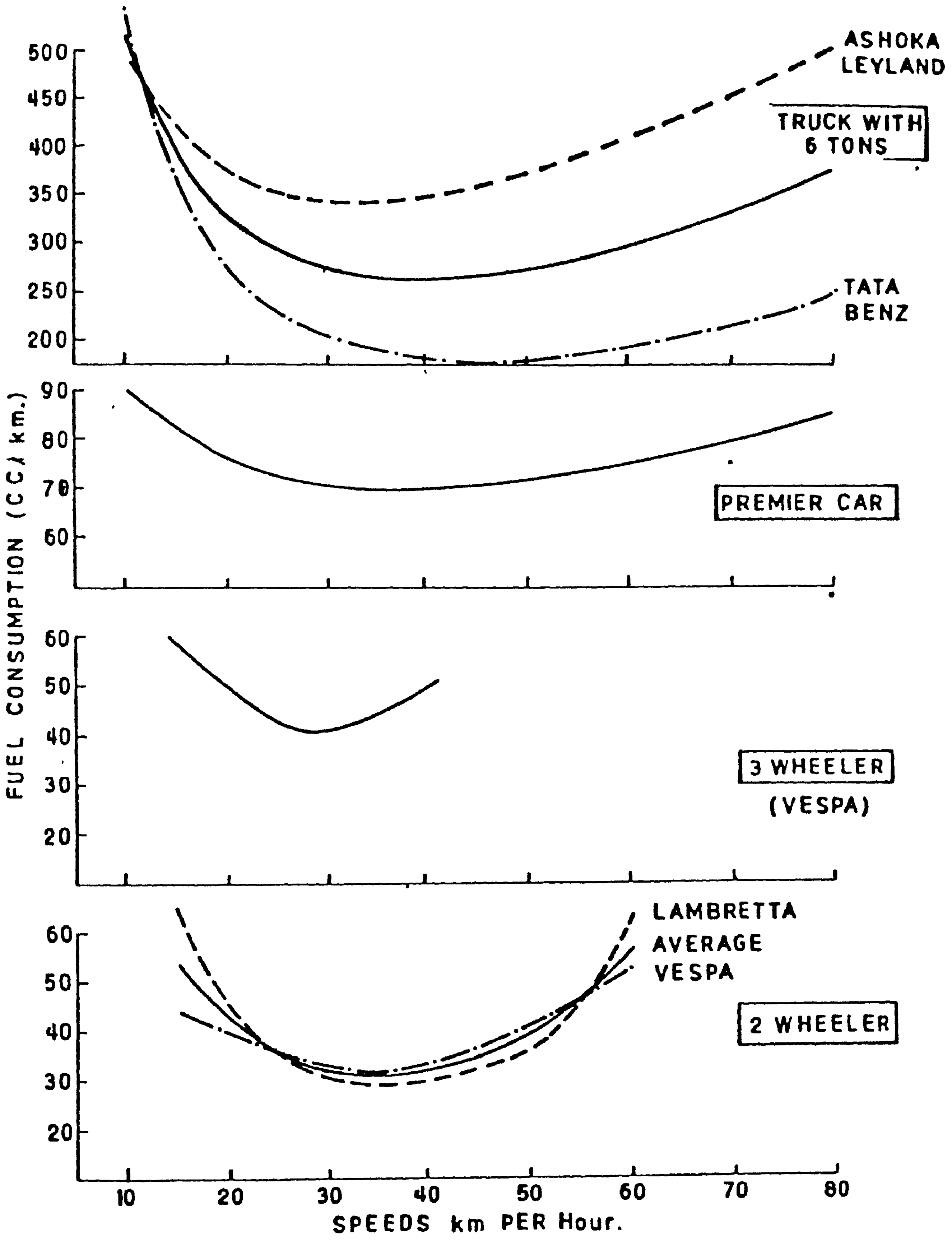


FIGURE 5.2: Effect of Journey Speed on Fuel Consumption

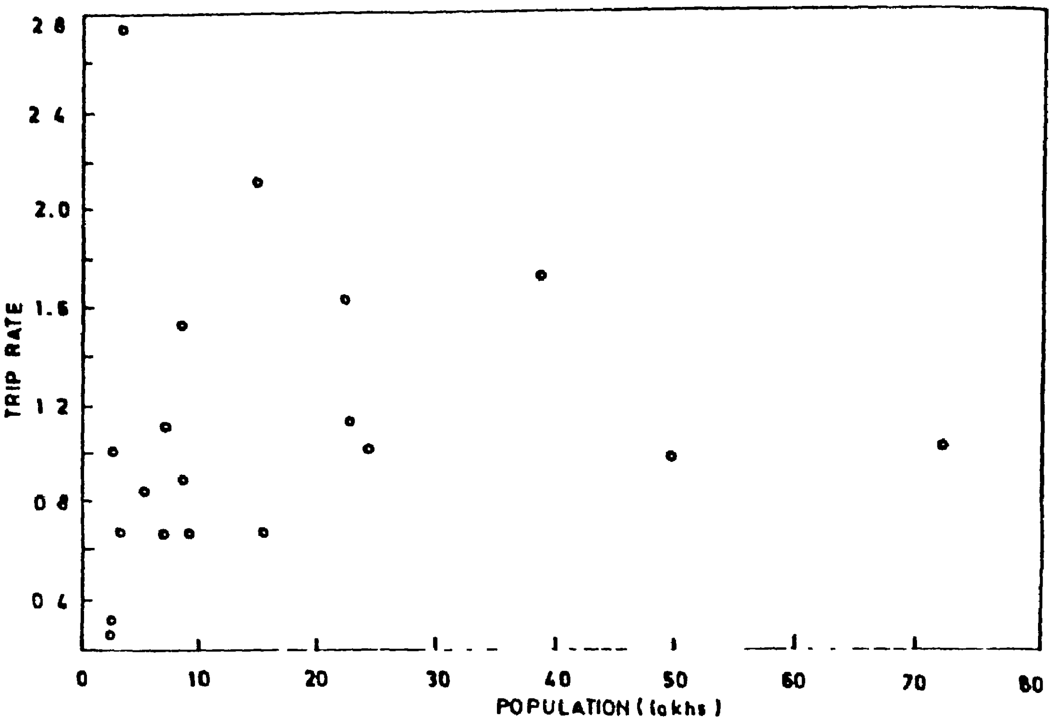


FIGURE 5.3: Trip Rate By Urban Size

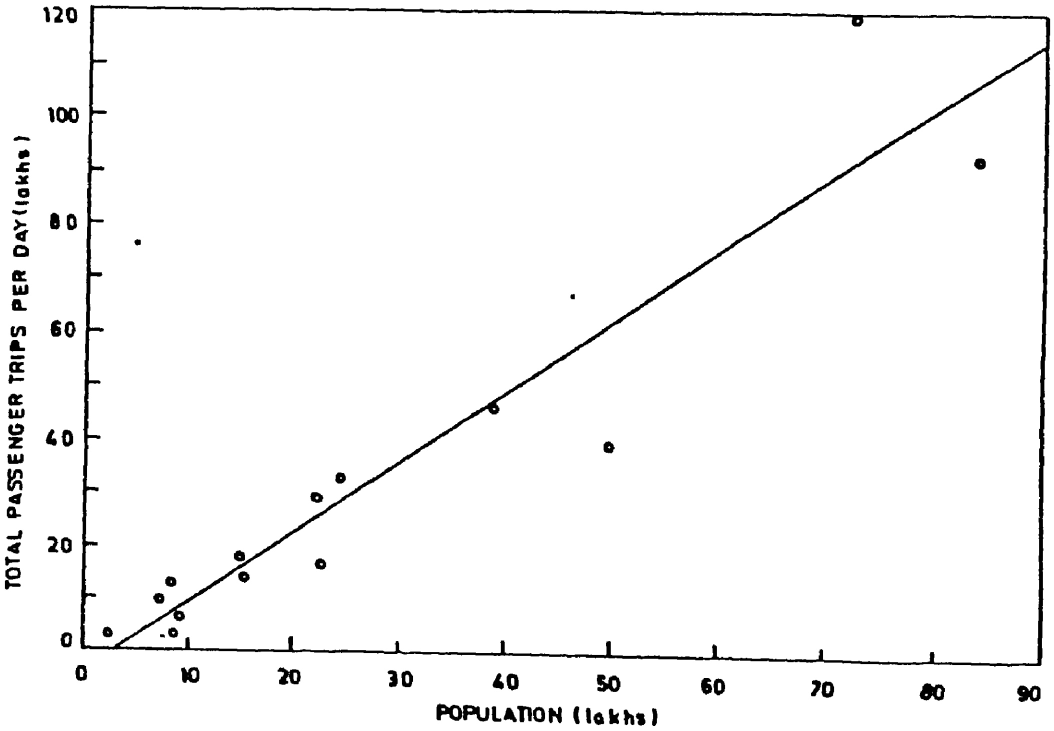


FIGURE 5.4: Trip Volume by Urban Size

5.4 URBAN TRAVEL DEMAND

We need to look at two components of urban travel demand. The first is the passenger trips. This is more dependent on the urban size (in terms of population) and the economic structure of the city. The second component is the average trip length. This is dependent more on the form and structure of the urban area and the manner in which land use is planned.

5.5 PASSENGER TRIPS

In order to examine the relationship between travel demand (in terms of passenger trips)and urban size/economic structure of the city a sample of 20 Indian cities from different population streams was selected. The data (TABLE 5.7) pertains to 1977-78, the period for which NSS data from the Central Statistical Organisation is available regarding trips per day as well as proportion of bus passengers in 1977-78 (obtained from the public transport undertakings). The total trips is computed for 14 cities. It can be seen that the trip rate does not show any relationship with urban size (FIGURE 5.3). However the total number of trips is closely related to the population of the city (FIGURE 5.4). This is also clearly brought out by doing a regression analysis using this data.The results of this is summarised below:

Dependent Variable	Independent Variable	Constant Term	X Coefficient	R^2
Trip Rate	Consumption Expr.Per capita	.06 (9.17)	.01 (1.67)	0.19
Trip Rate	Population	1.08 (1.74)	.0007 (0.12)	.0008
Trips	Population	-3.89 (0.32)	1.30 (10.0)	.89
Trips	Employment	-1.65 (0.17)	3.93 (12.67)	0.93
Log (Trips)	Log(Population)	-0.11 (0.11)	1.09 (9.08)	0.87

[Figures in brackets give the t-statistic].

The analysis establishes a significant linear relationship between the total trips per day and population of the city.

A number of traffic studies by different organisations done in the 1980's gives us some recent data relating to trips. The data from these studies in summarised in (TABLE 5.8). An analysis of this data indicates poor relationship between trip rate and population, but yields the following significant linear relationship between total trips (T) and population (P).

$$T = \underset{(0.20)}{-2.39} + \underset{(13.87)}{1.11P} \qquad R^2 = 0.88$$

t - statistic in brackets

TABLE 5.7: Urban Demand For Selected Cities 1977-78

City	Pop. (lakhs) (P)	Con. Exp. Per-capita (C)	Avg. Trip length kms. (L)	Employment (lakhs) (E)	Trip Rate (R)	Trip (Lakh/ day) (T)
Hyderabad	22.72	65.3	7.6	6.44	1.12	16.18
Gauhati	2.62	72.8	6.4	0.90	0.26	2.88
Ahmedabad	22.44	66.8	7.3	6.50	1.63	29.10
Bangalore	24.73	65.5	10.6	6.81	1.01	32.40
Mangalore	2.74	65.5	6.2	1.04	1.01	*
Indore	7.34	65.5	14.3	2.13	1.11	*
Bombay	72.38	118.1	10.8	26.28	1.03	119.75
Pune	14.92	79.8	7.9	4.51	2.12	17.56
Cuttack	2.84	70.1	17.8	0.86	0.32	*
Ludhiana	5.35	82.5	6.8	1.70	0.84	*
Jaipur	8.76	68.8	6.5	2.41	0.88	3.00
Coimbatore	8.54	64.8	9.8	2.81	1.52	12.91
Madras	38.89	74.7	6.9	10.29	1.72	46.07
Kanpur	15.44	60.8	5.7	4.25	0.67	13.84
Lucknow	9.39	60.8	5.8	2.61	0.67	6.14
Moradabad	3.22	60.8	7.9	0.87	0.67	*
Varanasi	7.28	60.8	4.5	1.95	0.67	9.6
Calcutta	84.19	108.9	5.8	26.20	0.86	92.9
Chandigarh	3.55	125.7	6.6	1.22	2.74	*
Delhi	49.90	88.1	11.2	15.91	0.97	38.9

* Data not available

TABLE 5.8: Trip Data From Traffic Studies

City	Year of Study	Population in 1981 (lakhs)	Projected pop. (P) for year of study (Lakhs) (P)	Passenger trips (T) Lakhs	% Share of Public Tpt.	Cycle
Calcutta	1984	91.9	98.1	86.1	na	na
Bombay	1986	82.4	96.9	113.4	67.3	na
Delhi	1981	57.3	57.3	39.1	59.7	17
Madras	1984	42.9	47.0	45.9	75.7	14
Hyderabad	1986	25.5	30.3	23.9	43.8	25
Pune	1986	16.9	20.6	20.4	31.5	28
Kanpur	1987	16.4	19.0	8.0	4.8	51
Jaipur	1983	10.2	11.2	9.8	25.5	43
Patna	1985	9.2	11.3	10.5	23.1	28
Coimbatore	1985	9.2	10.1	8.3	61.4	24
Vadodara	1985	7.4	8.9	11.6	43.1	25

This equation can then be used to project trip volumes for Indian cities in future years on the basis of projected population for each city.

5.6 TRIP PURPOSE

The purposewise trip analysis (TABLE 5.9) shows that work trips account for the major share. In all cities the share of work trips is more than 30%. Bombay has the highest share of work trips followed by Madras and Delhi. Trips for education range between 30-49% for majority of the cities, while the other trips for shopping, social visits, entertainment etc. account for 20-30% of the total trips. Since work and education trips account for 70-80% of all trips, public transport and rapid transit systems can, and should play an important role in urban transport.

5.7 MODAL SPLIT OF TRIPS

Walk trips form an important part of the total trips in Indian cities (TABLE 5.10). It is important to note that the share is significant in almost every urban centre irrespective of its size. This underscores the urgent need for urban planners to pay attention to the needs of pedestrians in designing cities.

TABLE 5.9: Purposewise trips for various cities

City	Percentage of Trips Work	Education	Other Trips
Bangalore	40	13	38
Bombay	64	19	17
Coimbatore	50	39	11
Hyderabad	53	34	13
Kanpur	31	39	31
Madras	52	30	18
Pune	42	33	25
Thane	33	47	20

TABLE 5.10: Share of Non-Motorised Transport in Trips

City	Population 1981(Lakhs)	% of Share (in total trips) Walk	Cycle	Cycle Rickshaw
Delhi	57.3	49.1	8.8	1.4
Madras	42.9	28.1	10.7	1.1
Hyderabad	25.5	19.8	21.9	4.7
Pune	16.9	38.9	17.1	-
Kanpur	16.4	43.1	29.2	11.6
Jaipur	10.2	39.5	26.5	2.7
Patna	9.2	35.8	12.5	17.6
Coimbatore	9.2	44.5	13.3	-
Vadodara	7.4	40.1	15.1	1.6

TABLE 5.11: Modal Split of Passenger Trips

City	Year Study	Study done by	Population in base year	Share in Non personalised transport			Passenger Trips Public Transport				
				Car	2W	Cycle	Rail	Bus	Taxis	3W	Other
JUMBO CITIES											
Calcutta	1984	CMDA	98.1	(not given)			20	72	-	-	8
Bombay	1986	BMRDA	96.9	8	4	na	33	34	10	11	-
Delhi	1981	DDA	57.3	6	11	17	na	60	<1	3	3
Madras	1984	HHDA	47.0	2	5	15	13	63	<1	1	1
OTHER METROS											
Bangalore	1982	IIM	31.2	3	9	15	-	61	-	4	8
Hyderabad	1986	CIRT	30.3	na	20	26	-	44	1	3	7
Ahmedabad	1985	CRRI	29.6	8	24	21	-	34	-	13	-
Pune	1986	CIRT	20.6	2	28	28	1	31	-	10	-
Kanpur	1987	CIRT	19.0	2	19	52	2	3	-	2	20
Patna	1985	CIRT	11.3	@	27	20	-	16	-	*	37
Jaipur	1983	CIRT	11.2	@	20	44	-	25	-	*	11
Lucknow	1985	CRRI	11.0	6	12	30	-	29	-	*	19
Coimbatore	1985	CIRT	10.1	@	10	24	-	62	-	2	2
OTHER CITIES											
Indore	1985	CRRI	9.7	9	14	16	-	54	-	7	-
Vadodara	1985	CIRT	8.9	@	19	25	-	43	-	10	3
Varanasi	1985	CRRI	8.8	4	11	21	-	39	-	5	20
Cochin	1978	NATPAC	7.7	6	3	14		70	<1	1	6
Ludhiana	1985	CRRI	7.2	9	19	23	-	35	-	7	7
Calicut	1980	NATPAC	6.1	6	3	11	-	76	<1	3	1
Trivandrum	1977	NATPAC	5.7	13	5	20	-	60	1	1	-
Chandigarh	1985	CRRI	5.3	10	15	15	-	54	-	2	4
Moradabad	1985	CRRI	3.8	8	9	25	-	40	-	*	18
Cuttack	1985	CRRI	3.8	4	5	8	-	77	-	*	6
Mangalore	1985	CRRI	3.5	6	7	na	-	77	-	8	2

@ Included in 2 wheelers
* Included in others

Bicycles also account for a substantial share in the total trips. It varies between 8 to 30 per cent, with some cities like Hyderabad, Pune, Kanpur and Jaipur having more than 3 to 4 lakh bicycles. It will be noticed that the share of cycle trips is not related to the size of the city. It is more dependent among other factors on the structure of the city and the extent to which public transport is available. From the perspective of protecting the environment and conserving energy, use of cycles should be encouraged. This would be possible only if we a) plan for smaller self contained urban areas and b) keep the needs of the cyclists in mind in planning our road networks.

Suburban rail systems are available mainly in 3 cities - Bombay, Calcutta and Madras. Of these it is only in Bombay that the rail system carries a substantial amount of the urban traffic (33 per cent of the total passenger trips). No doubt a rail based system is the most desirable for minimising energy consumption. However, the capital investments required for rail based rapid transit systems are extremely high and the gestation period for such projects is at least 10 years. In the present study we have restricted the analysis to road based systems.

The shares of different forms of transport in the trip demand for road based transport is shown in TABLE 5.11. The data given for 24 cities, is drawn from several traffic studies done by different agencies in the last 5 to 6 years. There appears to be no clear relationship between the size of the city and the modal split. However, the following general trends can be noted:

- For cities with population less than 1 million, there is no correlation between city size and share of pubic transport or share of cycles in total trips. However, in the metropolitan cities share of public transport increases and share of cycles decreases as population increases (FIGURES 5.5 and 5.6);

- The public transport share in the densely populated cities of North India is low, but generally increases with city population;

- In South India, particularly Tamil Nadu and Kerala, the public transport share is high, irrespective of the size of the city;

- 3-Wheelers appear to be more popular in the Southern cities;

- The use of car and taxi is very high in Bombay, where commercial and business activity is high;

- 2-Wheelers have become a popular mode accounting for 25% of trips in many cities.

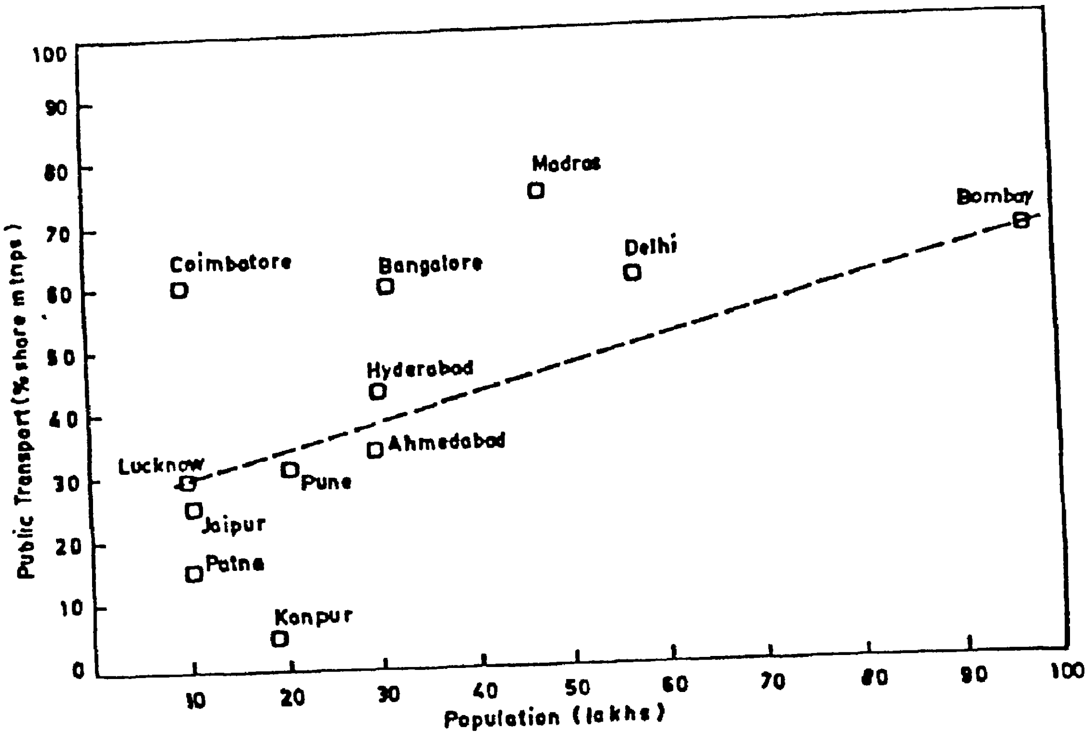


FIGURE 5.5: Share of Public Transport by Urban Size

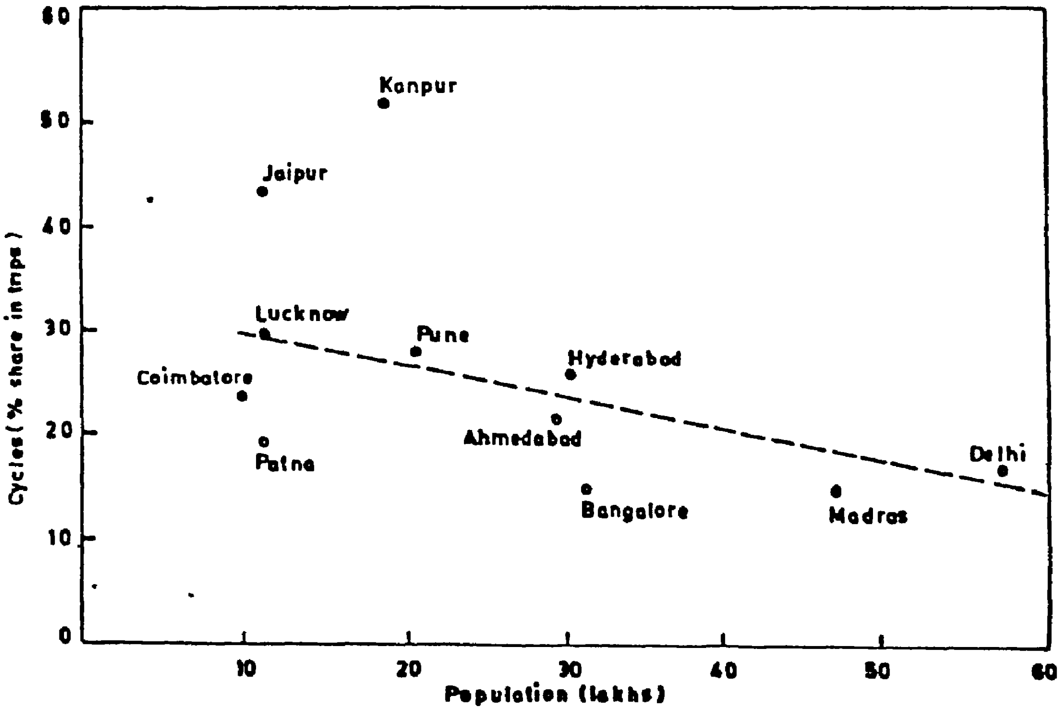


FIGURE 5.6: Share of Cycle by Urban Size

5.8 SHIFTS IN MODAL-SPLIT PATTERNS

As a city grows there is a shift in modal patterns (TABLE 5.12). In Delhi 36 per cent of the trips in 1957 was performed by cycles. But as the city expanded average trip lengths increased and a shift to bus transport took place. The bus and 2 wheeler shares increased to 59 per cent and 11 per cent respectively with the cycle share dropping to 17 per cent.

In Bombay one notes a downward trend in the share of mass transport from 84 per cent in 1971 to 67 per cent in 1986. The switch has been to personalized modes like car and 2-wheelers. But the greater increase has been in hired modes, like taxi and 3 wheelers.

The modal shifts in both these metropolitan cities has been in a direction involving higher fuel consumption per passenger kilometer - an undesirable trend indeed.

TABLE 5.12: Changing Patterns of Transportation in Delhi & Bombay

City:	Delhi		Bombay	
Year:	1957	1981	1971	1986
Total trips (lakhs)	11.3	39.0	56.3	113.4
% Share of Mode				
Rail	0.4	1.6	41.5	33.4
Bus	22.4	59.7	41.7	33.9
Car	10.1	5.5	6.1	7.6
2 Wheeler	1.0	11.1	1.5	3.6
3 Wheeler	7.8	0.8	-	11.7
Taxi	4.4	0.2	9.2	9.8
Cycle	36.0	17.0	n.a.	n.a.
Others	17.9	4.1	-	-

TABLE 5.13: Mobility and Congestion Indicators for Select Cities

City	Road Length (Kms) per		Road Area as % to Total Area	Vehicles* per Million Population	PCU's+ per Km of road
	1000 Population	100 Sq. Kms.			
Calcutta	.09	148	6.4	223	256
Bombay	.17	234	n.a.	407	230
Delhi	.28	357	n.a.	1148	331
Madras	.39	292	17.0	250	56
Ahmedabad	.35	974	5.6	561	127
Bangalore	.41	687	17.0	763	150
Kanpur	.58	322	4.1	426	51
Pune	.31	375	11.6	713	175
Jaipur	.24	120	12.1	951	324

* Excluding trucks;

+ PCU = Passenger Car Units [1 Bus = 3 pcu, 2 Wheeler = 0.5 pcu, Car, Taxi, 3 Wheeler = 0.5 pcu]

TABLE 5.14: Traffic Fulfillment and PCU's - As percentage of Total Motorised Trips/PCU's

City	Cars & Taxis Trips	Cars & Taxis PCU	2-wheelers Trips	2-wheelers PCU	3-wheelers Trips	3-wheelers PCU	Bus Trips	Bus PCU
Bombay	13	62	7	24	18	8	61	6
Delhi	7	31	14	55	4	6	75	8
Madras	2	42	7	45	2	6	89	7
Bangalore	4	31	12	52	5	7	79	10
Hyderabad	6	24	24	62	4	11	66	3
Pune	3	21	39	60	14	12	44	4
Kanpur	10	17	70	73	10	4	10	6
Jaipur	16	28	24	60	12	4	49	8
Lucknow	11	25	12	65	13	4	50	6
Average	8	35	16	50	10	6	66	7

5.9 MODES OF TRANSPORT AND ROAD CONGESTION

The congestion in roads can increase either because the road length is inadequate for the traffic carried or due to the predominance of personalised modes of transport which occupy more road space per passenger carried. In both these aspects there is a wide variation between cities (TABLE 5.13).

Calcutta has inadequate road length, while in Bombay the PCU's per km of road is high because of large population of cars, two wheelers and three wheelers. Madras has lower congestion, partly because of larger road length and partly because of higher component of public transport. [To some extent the data in TABLE 5.13 does not present a full picture since only road length is given and not total road surface area, e.g. in terms of road length per thousand population Kanpur appears best, but more than 70 per cent of the roads are less than 2 lanes and only 12 per cent more than 2 lanes].

The share of PCU'S of personalised vehicles is quite out of proportion to the share of traffic fulfilment (TABLE 5.14). The average trip served by these vehicles is 24 per cent whereas in terms of PCU's, these vehicles account for 85 per cent. On the other hand public transport buses, which account for only 7 per cent of PCU's, meet 66 per cent of trip demand in these metropolitan cities.

The share of personalised vehicles in total trips varies from a low of 9 per cent in Madras [where there is a good bus system] to as high as 80 per cent in Kanpur [which has hardly any public transportation system]. A higher share of personalised modes has serious implications not only in terms of energy, but also road congestion. The present wide variation between cities reveals a lack of planned policy. It is this lack of policy that has led to the shift in travel choice to personalised modes, with utter disregard to road capacity and energy consumption.

5.10 MODES OF TRANSPORT AND ENERGY IMPLICATIONS

Data on energy consumption by different modes of transport in various cities is not collected on a regular basis. However, on the basis of studies done by NATPAC for some cities, we can see the variation across some cities in fuel consumption per capita (TABLE 5.15).

It is clear that the fuel consumption is dependent on the pattern of transportation. Where public transportation share is higher, fuel consumption is lower, eg. in Cochin. Increased share of car or 2 wheeler modes, like in Trivandrum, Pune and Delhi leads to higher per capita consumption. The increase in share of fuel consumption by these modes is disproportionately more than the increase in share of passenger trips carried by them.

TABLE 5.15: Modewise Fuel Consumption for Select Cities

	Trivandrum	Cochin	Calicut	Jaipur	Pune	Delhi	Bombay
	Fuel Consumption by Different Modes [% to total]						
Bus	39.3	66.6	71.7	7.1	14.2	38.1	21.3
Car	46.2	21.9	16.1	12.6	22.5	29.2	43.6
2 Wheeler	9.4	7.0	7.1	78.6	49.3	30.5	0.9
3 Wheeler	0.2	3.4	5.0	1.7	14.0	1.6	-
Taxi	4.9	1.1	0.2	-	-	0.5	34.2
Total Consumption of Oil per day (lit)	13.6	10.4	13.8	25.2	55.0	355.7	963.4*
Consumption per '000 Population (lit)	22.9	12.7	21.9	19.1	26.3	48.5	98.2
Consumption per hundred Passenger Trips (lit)	73.5	49.2	64.0	43.7	48.3	73.6	195.5

* Excludes consumption by rail mode

In Bombay the higher use of car and taxi has led to a very high per capita fuel consumption (in spite of a fairly high public transport share). Further, trip lengths in Bombay are also much higher because of the linear form of the city resulting in very high consumption per passenger trip. Clearly Bombay is the least energy efficient in urban transportation.!

As a city grows, there is an increase in the number of trips by modes using commercial energy (conversion of walk and cycle trips to motorised modes). Trip lengths also increase as the city expands. The result is increased energy consumption per capita. This is illustrated by the data pertaining to Delhi (TABLE 5.16). A point to be noted is the shift from hired fast modes to 2 wheelers and a shift from cycle trips to bus trips. Even though trip lengths increased from 1969 to 1981 the energy consumption per hundred passenger trips reamined the same because of increase in share of public bus transport and reduction in share of cars in person trips.

TABLE 5.16: Transportation Trends in Delhi 1957-1981

	Modal Split of Trips %			Trip Length (kms)			Share in Fuel Consumption		
	1957	1969	1981	1957	1969	1981	1957	1969	1981
Cycle	36.0	28.0	17.0	5.0	4.8	3.8			
Bus	22.4	39.6	59.7	5.0	6.6	8.6	10	16	38
Car	10.1	15.1	5.5	4.0	5.1	8.1	35	52	29
2 Wheeler	1.0	8.4	11.1	4.5	5.6	7.3	2	18	30
3 Wheeler	7.8	3.9	0.8	5.0	4.8	4.4	30	10	2
Taxi	4.4	1.2	0.2	5.0	4.8	4.4	23	4	1
Others	18.3	3.4	5.7						
Energy Consumption in kilolitres of oil per day							63	113	283
Energy Consumption per '000 population (lts.per day)							31.3	33.5	49.4
Energy Consumption per '000 trips (litres)							55.7	72.4	72.6

5.11 IMPACT OF PUBLIC TRANSPORT ON ENERGY AND CONGESTION

It is clear that from the points of view of optimizing road space and energy use increase in the share of public transport is desirable. The comparison of public transport (bus) with other modes is clearly brought out in terms TABLE 5.17 of PCU'S and energy for meeting 1 million passenger kilometer of transport demand.

A car consumes nearly 5 times as much energy as a bus while a 2 wheeler consumes 2.5 times for meeting the same travel demand. What is even more critical is the number of vehicles required and the resulting congestion on the roads. You need 40 times as much road space if you are using a car instead of a bus. 2 Wheelers are even worse in terms of demand for road space. The cost effective solution desirable is obviously to move more people with less vehicles and less energy by increasing the share of public transport.

The consequences of increasing the share of public transport can be seen in the scenarios for Bombay summarised in TABLE 5.18 where 3 alternatives for Bombay are examined for meeting the projected traffic demand in 2001.

5.12 MODES OF TRANSPORT AND COST IMPLICATIONS

The cost per kilometer for operation works out to Rs. 6.59. This is on the basis of average cost of operation of the nationalised city bus undertakings. The cost of operation of other modes can be estimated on the basis of annual run and fuel consumption as assumed earlier and prevailing costs. This is shown in comparison to the bus mode in TABLE 5.19. The cost of operation for 2 wheelers and 3-wheelers is 3 times and in the case of cars 10 times compared with that for a bus. Fuel costs for a car in 13 times and that for a 2 wheeler 7 times that for a bus.

TABLE 5.17: Energy and PCU Requirements of Different Modes

Mode	Average ccupancy	Avg.Kms. Run/Day	Energy Efficiency Kms/Litre	Requirements for 1 Million PKM			
				Pcus	Index Bus=1	Energy G Cal	Index Bus=1
Bus	40	225	3.5	333	1.0	62	1.0
Car	2.6	30	10.0	12820	38.5	303	4.9
2 Wheeler	1.4	20	35.0	17857	53.6	160	2.6
3 Wheeler	1.7	120	25.0	4901	14.7	185	3.0

5.13 MODES OF TRANSPORT AND AIR POLLUTION

The liquid fuels consumption is significant in urban areas. The composition of exhaust from motorised vehicles in cities is characterised by large amounts of carbon monoxide, hydrocarbons and nitrogen oxides. In the absence of any control of the emission from vehicles, exhaust gases contribute significantly to urban air pollution. These pollution problems are further compounded in cities where atmospheric conditions are stable and there is no vertical mixing or motion of air. It is estimated that vehicular emission account for about 60 per cent of the total air pollution in cities.

There is at present no system of monitoring emissions from vehicles operating in Indian cities and no data is available on total emissions by different urban transport vehicles. However, a study by the Indian Institute of Petroleum in 1985 has estimated on the basis of tests on vehicles the emissions per kilometre for different Indian vehicles (TABLE 5.20). Here again we see the advantage of using a bus for meeting same travel demand the bus causes only about one-sixth the pollution as compared to other motorised modes.

It is significant to note that the emission from vehicles in India is for higher than the standards specified by EPA in USA - 2.12 g/km of CO, 0.25 g/km of HC and 0.63 g/km of NOX for cars. Air pollution from vehicles in India, particularly in urban areas is a matter of serious concern. One study done by Bharat Heavy Electricals Limited estimates the pollution damage cost to be around Rs. 30/kg. vehicular emissions are not checked and regulations imposed, the risk to life will acquire dangerous proportions.

TABLE 5.18: Alternative Modal Choice for Bombay

Mode	Alternative I Share in %		Alternative II Share in %		Alternative III Share in %	
	PCU's	Trips	PCU's	Trips	PCU's	Trips
Bus	1	44	5	70	14	87
Taxi	62	14	49	7	53	3
2-Wheelers	13	16	12	9	10	4
3-Wheelers	6	20	7	11	7	4
Vehicles(Lakhs)	8.55		4.67		2.05	
PCU's (Lakhs)	7.33		4.10		1.91	
PCU's/Road km	516		285		135	
Energy (TOE/day)	2041		1450		1064	

Basis of calculations
Bus Strength per lakh population I - 25; II-40; III-50
Rail Share kept at 21%
Trips in 2001 = 144.6 lakhs
Trip length = 9 kms
Share in trips above given only for road based trips. After accounting for bus share in each alternative, balance split as per present split i.e. car 23%, Taxi 30%, 3-Wheelers 36%, 2-wheelers 11%.

TABLE 5.19:Costs of Operation of Different Modes

Item	Cost Per Km in Paise			
	Bus	2W	3W	Car
Petrol	100	25	36	85
Taxes	17	2	1	3
Insurance	-	3	2	12
Interest	139	20	11	120
Depreciation	45	13	6	53
	239	-	28	120
Repairs	119	8	12	16
Total Cost	659	72	96	409
% of fuel cost to total cost	15	36	37	21
Occupancy	40	1.4	1.7	2.6
Cost/PKM (Paise)	16.5	51.4	56.5	157.3
Index (Bus=1)	1.0	3.1	3.4	9.5
Fuel Cost/PKM Paise	2.5	18.5	21.1	32.7
Index (Bus=1)	1.0	7.4	8.4	13.1

TABLE 5.20: Emissions From Vehicles

	Emissions in grams/km					Emissions Index	
Mode	CO	HC	NOX	Particulates	Total	gms/PKM	Bus=
Bus	22.8	8.8	43.1	1.4	76.1	1.9	1.0
Car	24.0	3.6	1.6	-	29.2	10.8	5.7
2 Wheeler	8.3	5.2	-	-	13.5	9.6	5.1
3 Wheeler	12.2	7.7	-	-	19.9	11.7	6.2

Source Ref. GOI (1985)

5.14 REDUCING TRANSPORT ENERGY REQUIREMENTS

There are two basic ways in which energy need for transport can be reduced - the total travel demand (in terms of passenger kilometers.) can be reduced and this demand can be met by more energy-efficient means. The former implies arranging land-use so that there is less need to travel, and adoption of urban structure, in terms of shape and density, which will reduce trip lengths. The latter implies land-use patterns and transportation policies which will be most conducive to public and non-motorised transport. This should be coupled by technology improvements for more energy efficient transportation systems.

5.15 DEFINING ENERGY EFFICIENT STRUCTURE

How can one identify spatial structures which reduce the travel demand. The first approach could be to make an empirical comparison of energy consumption in different cities. If we can correlate energy consumption patterns to some structural variables we can draw conclusions about the energy implications of different spatial structures. But this approach is beset with numerous difficulties. First, there are problems of defining and quantifying different factors specifying urban form. Second, the cities may not reflect any specific urban form and different areas within a city may have different structures. Third, considerable variation in energy patterns due to socio-economic and other 'non-spatial' factors may obscure any variation that might be attributed to spatial structure. In the context of India, lack of detailed data regarding urban transport rules out this approach.

A second approach, which has most commonly been employed is to estimate the energy requirements associated with alternative hypothetical spatial patterns. Theoretical studies of this nature in developed countries have ranged from the highly abstract (e.g. Hemmens 1967; Schneider and Beck, 1973) to those which consider alternative development patterns for existing geographical areas (e.g. Clark, 1974; Roberts, 1975). This approach, no doubt is open to criticism, that models are an over oversimplified view of the real world and the results may not have any direct policy application. However, this approach, does help in at least arriving at orders of magnitude of changes in travel demand purely due to changes in urban structure. In India there is lack of data on spatial distribution of energy demand which are sufficiently disaggregated to permit exploration of its relationship with urban structural variables. We have adopted the second approach to explore the travel implication of different urban forms and densities.

5.16 URBAN SIZE AND TRAVEL DEMAND

The question of whether travel needs increase or decrease with urban size remains unresolved. There is great uncertainty and contradiction in empirical evidence. In one study (Maltby et al 1978) in the U.K., per capita energy use for transport was seen to decline with size of urban area from about 310 MJ/capita/week to 250 MJ/capita/week. On the other hand, a theoretical study, done by National Institute of Economic and Social Research using a gravity model, showed that for towns in UK the journey-to-work travel cost increased more than proportionately with population size. Average travelling costs per capita were 22% lower in settlements of 50000 than in those of 100000 and nearly 50% higher in settlements 250,000.

In the USA in one regression analysis based on data of 134 metropolitan areas, a significant correlation between per capita fuel consumption and total population was found (Stewart and Bennett 1975). On the other hand Keyes and Peterson (1977), using data from 49 metropolitan areas, found quite the opposite.

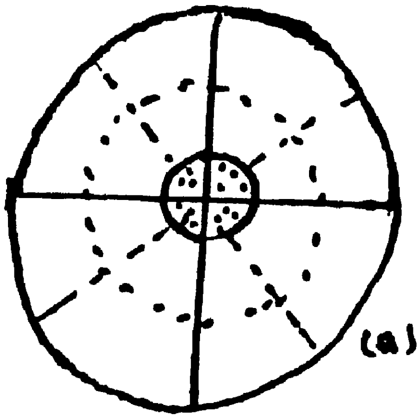
The apparently contradictory results are on account of the variety and complexity of factors that influence energy consumption in urban transport.

In an earlier section, we have seen that the data for Indian cities does not indicate any significant correlation of trips per capita with population. As far as trip length are concerned these are more dependent on urban forms than size.

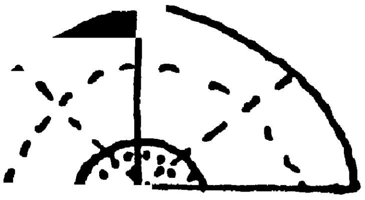
5.17 URBAN FORM AND TRIP LENGTH

Let us now look at the effect of urban form (shape and density) on travel demand. For this we make some calculations of average trip lengths for different hypothetical urban forms. Three types of cities are examined as shown below:

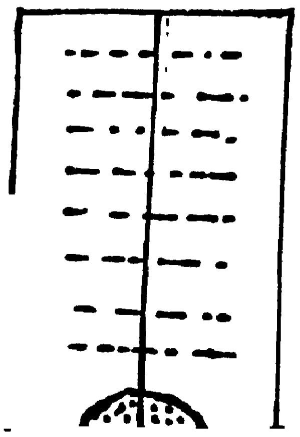
(a) Circular (like Delhi)
(b) Semi-Circular (like Madras)
(c) Rectangular or Grid (like Bombay)



(a)



(b)



(c)

Case (a): Circular Mononuclear City

We start with a circular city assuming all business activity to be concentrated at the centre. If the population of the city (in millions) is P and the density of residences is uniform at D person per hectare then travel demand T (in passenger bus) is given by:

$$T = \int_0^R 2\pi x \cdot x\, dx \cdot D \cdot 10^2 \qquad \text{where R = radial size of the city}$$

$$= \frac{200}{3} \pi R^3 \cdot D$$

But $100.\pi R^2.D = P.10^6$

Hence trip length TL is given by

$$TL = 2/3\ R = (200/3)\sqrt{P/\pi D}$$

or $$TL = 37.6\ (P/D)^{1/2}$$

Using the above relationship and a circuital factor of 1.3 (to account for access to radial roads) the average trip lengths for different size cities is given in (TABLE 5.21).

The variation in trip length as density and popuation changes can be seen clearly in FIGURE 5.7. One notes that density increases beyond 200 or 300 persons per hectare does not reduce trip lengths significantly.

Case (b): Semicircular Mononuclear City

It can be shown that the average trip length in a semicircular city is 2 times that in a circular city of same population and density.

TABLE 5.21: Trip Lengths for Different Sizes and Densities

Density (Persons/ hectare) population million	50	100	150	200	250	300	400	600
	Average Trip Length (kms)							
9	20.7	14.7	12.0	10.4	9.3	8.5	7.3	6.0
6	16.9	12.0	9.8	8.5	7.6	6.9	6.0	4.9
3	12.0	8.5	6.9	6.0	5.4	4.9	4.2	3.5
1.5	8.5	6.0	4.9	4.2	3.8	3.5	3.0	2.8
1	6.9	4.9	4.0	3.5	3.1	2.8	2.4	2.0
0.5	4.9	3.5	2.8	2.5	2.2	2.2	2.0	1.4

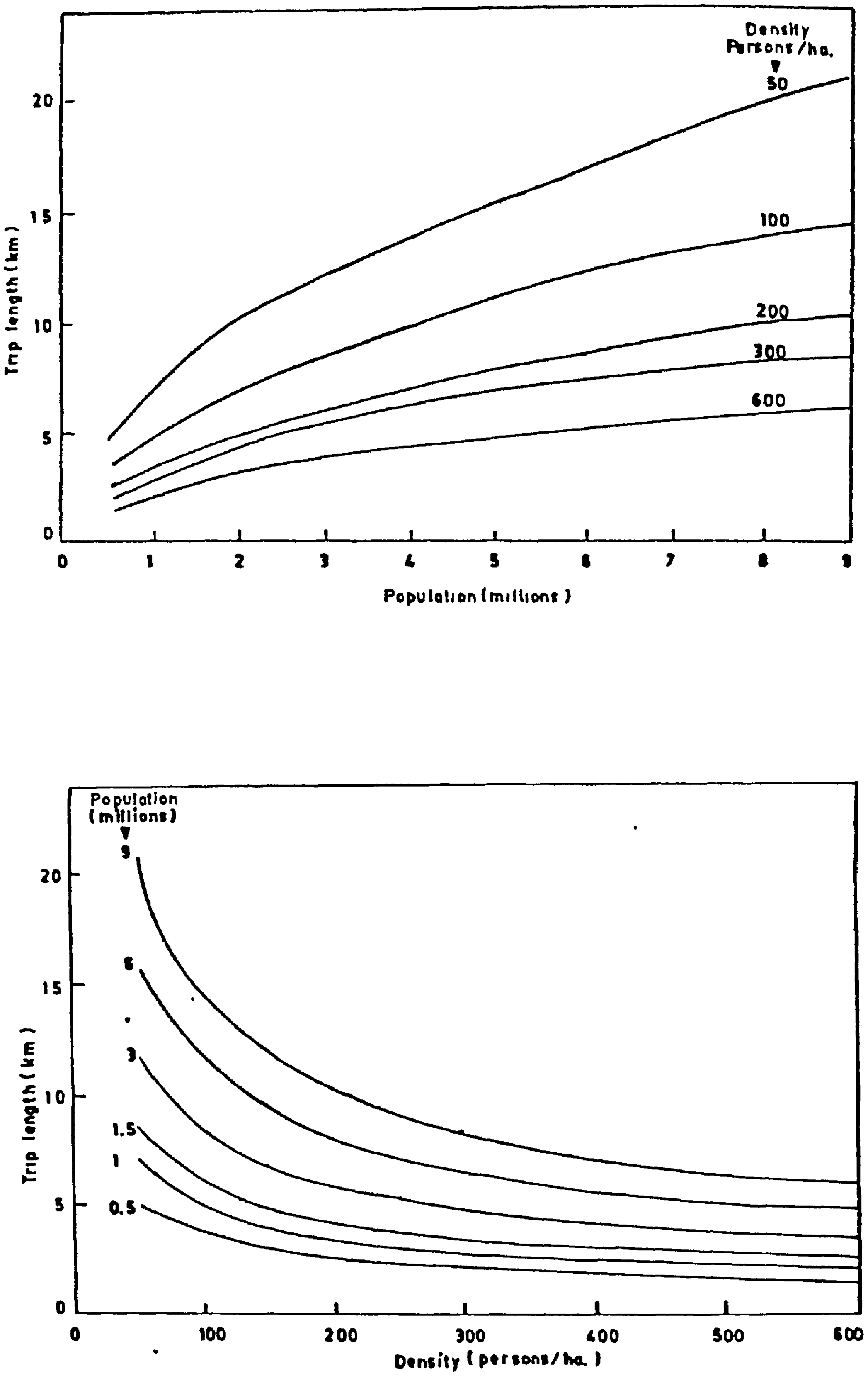


FIGURE 5.7: Trip Lengths for different urban size and different densities

Case (c): Linear a Rectangualr City

In the case of a city with a single linear arterial road and the CBD at one end of the city (like in Bombay) the average trip length is given by:

$$TL = \frac{W}{4} + \frac{L}{2}$$

where W,L are the width and length of the city respectively. If we assume the length to be n times the width we have:

$$D.nw^2 = P.10^4$$

and hence for such a city the average trip length is:

$$TL = 25(2\ n + 1/\ n)\ (P/D)^{1/2}$$

If n=8 (ie., length is eight times width) the trip length for the linear city will be 3 times that for a circular city.

If the CBD is at the centre of the city and not at one end, the trip length will be given by:

$$TL = 25\ (\ n + 1/n\ )\ (P/D)^{1/2}$$

Taking n = 8, we find that trip length for a rectangular city with CBD at the centre is 1.6 times that of a circular city.

Clearly then a circular form is more efficient from the point of view of travel demand. However, a rectangular form is better from the point of view of rapid transit rail systems or exclusive busways on arterial roads. There is then a trade-off and decisions have to be taken with reference to the specific conditions of each city.

5.18 MONONUCLEAR VS. POLYNUCLEAR CITIES

The normal tendency is for business and economic activity to concentrate in central areas with residential areas spilling into the suburbs leading to a mononuclear structure as discussed in the earlier section. If, however, it was possible to establish proper linkages between the place of work and residence, commutation could be substantially curtailed.

Suppose, for example, instead of a mononuclear large circular city, we are able to develop -- smaller circular sub-cities which are self- sufficient in terms of residence and work place then it can be shown that:

Travel Demand in Mononuclear City = $\sqrt{n}$ [Travel Demand in the n smaller modes nodes)

This means that if we plan the city as 2, 4, 6 or 8 self sufficient nodes instead of one large city, we can reduce energy consumption in transport by 30, 50, 60 or 65 per cent respectively.

The above analysis brings out the importance of urban design and land use planning in achieving substantial reductions in energy use in urban transport.

5.19 PROJECTIONS OF URBAN TRANSPORT DEMAND

A reliable forecast for total urban transport demand can be made only if we have disaggregated time series traffic data for different size and different types of cities. Data on other socio economic parameters, like income and employment structure would also be needed. In the absence of this, one can only made a rough assessement of the demand on the basis of some grouping of the cities into homogenous groups and arrive at the demand on a theoretical basis. This was attempted by the Study Group on Alternative Systems of Urban Transport set up by Government of India.

The parameters used by them for classifying the cities are detailed below:

(a) Population Size

Symbol	Population Range	Medium Population
I	8 M - 18 + M	13 M
II	4 M - 8 M	6 M
III	2 M - 4 M	3 M
IV	1 M - 2 M	1.5 M
V	0.5 M - 1 M	0.75 M
VI	0.25M - 0.5 M	0.375 M

(b) Urban Form

C - Circular
S - Semicircular
L - Linear

(c) Spatial Structure

M - Mononuclear	i.e. only one CBD
P - Polycentric	i.e. one CBD and other District Business Centres (DBCs)

In circular city, four DBC's are assumed in a ring corridor around the centre. In a semicircular and linear cases 2 DBC's are assumed.

In the division of employment activity between the CBD and DBC's we may have two options:

Uniform (U)	- where employment opportunities in DBC's and CBD are equal
or	
Non-Uniform (NU)	- where 50 per cent of employment is in CBD and balance equally shared among DBC's.

The residential population and densities are assumed to be as follows:

	C	S	L	
Inner Belt	20 %	20 %	10 %	@ 600 persons/hectare
Intermediate Belt	60 %	60 %	60 %	@ 250 persons/hectare
Outer Belt	20 %	20 %	30 %	@ 100 persons/hectare

On the basis of the above parameters, the classification of cities in India in 2001 is expected to be as shown in (TABLE 5.22).

The travel demand is worked out for each type using a gravity model of the type:

$$Tij = K P_i E_j D_{ij}$$

where Tij = number of '000 trips per day between residential zone i and activity centre j.

P_i = population of zone i (assumed to be concentrated at its centroid)

E_j = employment is '000 at activity centre j (Participation rate of 30 per cent is assumed)

D_{ij} = distance between residential zone i and activity centre j in Kilometers

K = a calibration constant

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TABLE 5.22: Expected Classification of Cities in 2001

Pop Category (million)	Circular			Semi Circular			Linear			Total
	PU	PNU	M	PU	PNU	M	PU	PNU	M	
8 +	-	3	-	-	-	-	-	1	-	4
4 - 8	1	1	-	-	1	-	-	-	-	3
2 - 4	-	2	-	-	1	-	-	1	-	4
1 - 2	-	4	5	-	1	1	-	2	2	15
0.5 - 1	-	12	18	-	1	-	1	2	2	36
0.25- 0.5	1	1	14	-	-	1	2	-	2	21
Total	2	23	37	-	4	2	3	6	6	83

The model was validated in the context of the specific case of the Delhi metroplitan region and found to approximate reasonably well to the actual traffic data.

On the basis of this model the average trip rate and trip lengths were worked out by the Study Group for the different classes of cities. The results are summarised in TABLE 5.22. 4.5

The total passenger trips for each size city, can be projected using the regression equation in Section 5.5. Utilizing the classification of cities as in TABLE 5.22 and the trip lengths as in Table 5.23. Using this the total travel demand for the 83 cities above 0.25 million population in the year 2001 is given in TABLE 5.24.

TABLE 5.23: Trip Rate and Length for Different Class Cities

Population (million)	Average Trip Length (Kms)								
	Circular			Semi Circular			Linear		
	Pnu	Pu	M	Pnu	Pu	M	Pnu	Pu	M
8 +	10.0	11.1	-	11.6	11.6	-	22.6	23.0	-
4 - 8	6.8	7.5	-	7.9	7.9	-	10.5	10.7	-
2 - 4	4.8	5.3	4.0	5.6	5.6	5.6	5.2	5.4	4.8
1 - 2	3.4	3.8	2.8	3.9	3.9	3.9	2.6	2.7	2.4
0.5 - 1	2.4	2.7	2.0	2.8	2.8	2.8	1.3	1.3	1.2
0.25- 0.5	1.7	1.9	1.4	2.0	2.0	2.0	0.7	0.7	0.6

Source: Report of "Study Group on Urban Transport Alternative Systems, Govt. of India.

TABLE 5.24: Projections of Urban Travel Demand

Population Range (Million)	Medium Population	No. of Cities	Population (Million)	Travel Demand BPKM per year
8 +	13	4	52	314.5
3 - 8	6	3	18	59.8
2 - 4	3	4	12	25.9
1 - 2	1.5	15	22.5	25.6
0.5 - 1	0.75	36	27	15.6
0.25- 0.5	0.375	21	7.9	1.4
Total		83	124.4	442.8

5.20 INCREASING THE SHARE OF BUS MODE

In the preceding sections we have clearly seen that the bus mode is advantageous from several angles. The other modes car, 2 wheeler and 3 wheeler compare very unfavourably for meeting the same travel (PKM) as summarised below:

	Fuel Consumption	Fuel Cost	PCU's	Emission	Total Cost
			(Index with Bus = 1)		
Car	4.9	11.8	38.5	5.7	9.5
2 Wheeler	2.6	6.8	53.6	5.1	3.1
3 Wheeler	3.0	7.0	14.7	6.2	3.4

We are now in a position to quantify these advantages on a rough basis for a modal shift taking place in the year 2000. We have adopted one possible scenario. In working out this the following assumptions have been made:

- Total travel demand for the 83 cities is as in TABLE 5.24;
- Of the total projected suburban rail rail traffic of 106 BPKM in 2000, 50 per cent will be for long distance suburban outside the city limits;
- Present modal split for public transport (as approximated from FIGURE 5.5) for the cities sizes I-VI will be 60, 55, 50, 45, 40 and 35 respectively;
- In the recommended scenario, public transport shares will be 85, 75, 70, 60, 55 and 45;
- The share of trips covered by cycle (as approximated from FIGURE 5.6) will be 10,15,20,25,30 and 35 for cities of grades I to VI respectively and average trip lengths for cycle will be 5,4,4,3,2 and 2 respectively
- The share of cars in trips at present is taken as 10 for Grade I cities, 8 for Grade II & III cities and 6 for the others. In the recommended scenarios the shares are 4 for Grades I - III and 3 for Grades IV - VI cities.
- The balance trips is split in the ratio 2:1 between 2 wheelers and 3 wheelers.

The results are summarised in TABLE 5.25. An increase in bus share from 57% to 80% leads to a saving of 11 lakhs tonnes of oil. The other advantages that ensue are a 54 per cent reduction in total vehicles on the road, a 36 per cent reduction in air pollution and a 33 per cent reduction in transport costs.

TABLE 5.25: Implications of Suggested Recommendations

	As per present trends					As per recommendation				
	Bus	Car	2W	3W	Total	Bus	Car	2W	3W	Total
Annual Passenger Kms (10^8)	205	33	80	40	358	288	14	36	20	358
Modal Split (%)	57	9	22	12	100	80	4	10	6	100
No. of Vehicles (10^3)	62	1173	7809	532	9576	87	488	3542	260	4377
PCU's (10^3)	186	1173	3904	532	5795	261	488	1771	260	2780
Fuel (10^3 TOE)	1270	1012	1277	733	4292	1786	421	579	359	3145
Emission (10^3 tonnes)	389	361	766	463	1979	547	150	347	227	1271
Cost (Rs. Crores)	3379	5254	4102	2237	14972	4754	2186	1861	1096	9897

Reduction obtained by implementing recommendations are:

Fuel	: 1.15 million TOE	(27 %)
Vehicles	: 5.20 million	(54 %)
PCU's	: 3.02 million	(52 %)
Emissions	: 0.71 million tonnes	(36 %)
Cost	: Rs. 5075 crores	(33 %)

The increase in the number of buses required in the recommended scenario is 25,000 buses. At today's cost this would mean an additional investment of Rs. 1,000 crores. If we add 30 per cent for investments in infrastructure we need only Rs. 108 crores per year till the turn of the century to provide the requisite additions to buses.

One disadvantage in the recommended scenario is that about half a million tonne of diesel fuel will be required in addition implying additional imports. This can be got over if two further measures are implemented:

- increasing the traffic carried by electrical suburban rail systems in metropolitan cities by 50 per cent more than that projected by the Railways (i.e. 26 BPKM more) giving a saving of 160 thousand tonnes of diesel

- improving fuel efficiency of buses from 3.5 kmpl to 4.5 kmpl leading to a saving of 400 thousand tonnes of diesel. [This could be done partly by technological improvements in bus design and partly by traffic management measures leading to less congestion and faster flow of bus traffic.]

The question that may be asked is, "Will people shift to public transport?" Experience in India shows that in cities where there is a clean, effective and efficient bus transportation (either public or privately operated) urban residents do shift to the bus mode. This is evident from the high percentage of bus mode in many cities in South India and the popularity of the privately operated 'charter bus' system in Delhi.

We, therefore, feel that the modal split suggested by us above is feasible. An imaginative policy for bus transportation providing for different types of services, like express, deluxe etc. to cater to different interests would have to be implemented to wean away commuters from personalised transport to buses. What is needed is the will of policy makers to implement such a policy. A change in industrial policy in the automotive sector would also be needed. There will have to be an accelerated production of fuel efficient buses designed specifically for urban transport and a cut back on production of cars and 2 wheelers.

CHAPTER 6

POLICY ISSUES

We know that urbanization is inevitable in the process of economic development. But, is the present pattern of urban growth suitable, from the point of view of optimal resource utilization? Definitely not. As cities expand, their energy budgets rise steeply. We cannot sustain the present trend of concentration towards bigger cities for long. Development on a sustainable basis would need a more balanced urban growth with accelerated development of smaller and medium-sized towns, on an ecologically-sound basis.

6.1 ISSUES IN HOUSEHOLD ENERGY

We have seen that, as households move from the countryside to the cities, their pattern of energy consumption changes. There is a transition from biofuels to commercial fuels. At the same time, biofuels, particularly firewood, do not lose their importance, and their supplies also need to be planned for. One factor that governs this choice of fuels is no doubt income on which energy planners have no control. However, the supply and pricing of fuels, which also influences fuel choice, are matters that are within the purview of policy makers.

The fuel mix chosen by a household depends on supply and pricing of fuels. The data available from the macro and micro level studies done so far is not sufficient to make any reliable forecasts regarding fuelwise requirements for household energy. However, from the foregoing analysis it is clear that the present urban energy system is inequitable, causing undue hardship to the urban poor. Government policies in regard to different fuels have been uncoordinated and sometimes adhoc. There is a need to draw up an integrated energy supply and pricing framework, keeping the specific problems of the urban poor in focus.

Supply Enhancement and Accessability

There are several different options that need to be considered to enhance supply and provide greater accessability of fuels to urban housholds.

In the short run, kerosene supplies need to be stepped up, ever if it means increasing imports. The public distribution system for kerosene will have to be streamlined and expanded to ensure that the poor households, particularly in smaller towns, get their basic fuel requirements, without resorting to the open market. Alternative methods of rationing, like the coupon system, of Sri Lanka, could be tried out so that intended benefits of subsidised supply reaches specifically targetted groups.

Production of LPG can be stepped up further. We need to examine whether the present system of retention price gives sufficient incentive to the oil companies to enhance LPG production.

In order to make LPG accessible to the urban poor we must
- develop smaller(say 4-5 kgs), safer cylinders
- reduce substantially the deposits required for connection
- develop cheaper LPG burners.

India has substantial reserves of coal. Therefore, in the medium term, we have to plan for coal to replace kerosene for cooking. But this would need development of smokeless coal-based fuels like briquettes, or gasification systems for producing coal gas. Government, at one time, did take up some pilot plants. But this has not been pursued vigourously. A coordinated policy needs to be drawn up by government to make coal as a major fuel in the household sector. This would need enhanced R & D in this area, proper pricing policies to provide incentives for the production of LTC and soft coke and stepping up investments for such programmes. (It may be mentioned here that the Republic of Korea has a massive programme for coal briquetting and 60% of its household energy needs are now being met by coal).

Firewood is not the best energy option. Yet, it does not seem possible to displace firewood, completely, in the near future. Even if LPG and kerosene supplies are stepped up, it may not be sufficient to meet the total energy needs of the urban poor. To cater to this need, lands in the fringes of towns should be identified and reserved for urban fuelwood plantations wherever possible. A planned, massive programme for such plantations around cities needs to be taken up immediately.

Firewood could then be used possibly in wood-gasifier systems more efficiently. This should be combined with biogas, produced from sewage and waste, to supplement LPG supplies and provide piped gas supply for cooking to all income groups. This could be tried out at least in the larger cities.

The policy decision that would have to be taken would be regarding the optimum balance between fuels and the pace at which the transition should take place. But this would require much detailed information on:

- households behaviour and parameters that govern fuel choice;
- costs of producing and distributing modern fuels;
- benefits and costs of enhancing biofuel supplies;
- human and environmental cost of present biofuel consumption;
- influence of price on consumer decisions;
- changes in the above parameters across regions and over time.

Unfortunately the data available at present is totally inadequate and one cannot lay down a clear policy direction. There is an urgent need to undertake comprehensive studies on a periodical regular basis on the above parameters to enable urban energy planners to take rational and optimum decisions in regard to supply and pricing policies.

Demand Management

Greater efficiency has to be given the highest priority. The potential it offers for reducing energy demand, without sacrificing living standards, is large. Efficiencies can easily be increased by a factor of two in typical stoves using biofuels. Improvements in kerosene and coal stoves is also possible. Propogation and distribution of improved cooking stoves, on a much larger scale, is an urgent necessity.

Consumer education and publicity programmes have to be taken up on a concerted basis to make people aware of the potential for energy savings, through use of improved stoves and more efficient cooking practices. We must encourage replacement of kerosene by electricity for lighting in poor households. This would require special schemes for giving light connections to households living in slums and EWS colonies on the lines of the 'one hut one light' scheme intiated in Tamilnadu. (Under this scheme each household was given one light point by the Electricity Board. The beneficiary did not have to pay any connection fees but only a flat monthly charge of Rs. 2.50). Incidentally, electrification of huts could indirectly facilitate other social programmes, like education, hygiene, etc.

Pricing

In cities pricing has a critical role to play in managing demand levels and guide fuel substitution. An integrated energy pricing framework needs to be drawn up keeping in mind the need for:

- reducing the burden on the poor;
- encouraging adoption of efficient technologies;
- dicouraging profligate use of energy;
- providing incentives for producers of biofuels and coke to enhance supplies.

Electricity and LPG are priced well below marginal costs. Since these fuels are used by the higher income groups, there is no justificatin for this. These prices can be rationalised, to bring them near marginal cost of supply, for the higher-income groups. The surplus revenue thus generated can be used to provide the poor with adequate supplies of low-priced kerosene, biogas from waste, and LPG, as alternatives to firewood.

Simultaneously, more control on the biofuel market will have to be exercised so as to regulate firewood trade and bring down wholesale and retail markups, so that the final buyer pays less.

6.2 POLICY ISSUES IN ENERGY FOR URBAN TRANSPORT

There is considerable scope for optimizing energy use in the urban transport sector. This can be achieved by:

Reduction in transport demand through--	Increase in energy efficiency through--
* Proper City Design	* Traffic Management
* Appropriate tariff policies	* Optimal modal mix
* Urbanization policies	* Technological development.

Designing of Cities

Urban planners do not normally take energy as a factor in designing cities. No thought is paid to the need or possibility of reducing travel demand through appropriate structuring of the urban areas. The accent in urban transport planning is of mobility rather than accessability.

On the basis of empirical studies conducted in different cities it can be concluded that travel demand and hence energy for transport can be reduced by :

* adopting higher densities and clustering of land uses;
* locating residential areas of workers employed in the service and trade centres in close proximity to their work places;
* modifying zoning policies to allow for a greater mix of various land uses;
* locating public service facilities close to intended consumers;
* planning for a poly-nucleated urban structure with a large number of selfsufficient neighbourhoods linked by arterial highways.

Tariff Policies

Public transportation (both rail and bus) has been heavily subsidised. This has had two effects. People who have been compelled to live in far-flung areas have not felt the pinch; hence business areas have continued in centre city.

Secondly, sufficient funds are not generated for requisite investment in maintenance and expansion of the system. This leads to a deterioration of transport services.

A suitable incentive and disincentive tax system should be evolved to force businesses away from the central business district.

An appropriate system of incentives and disincentives should be evolved to promote car and van pooling.

Urbanization Policies

The urbanization experience in India has shown that our larger cities have been expanding while the smaller ones have stagnated or declined. As a city grows in size, not only are more people travelling greater distances, but we are also more dependent on motorized vehicles. This is a ridiculous situation.

Our urbanization policies have to be reoriented. We cannot afford our large cities to grow. We want our smaller ones to, instead.

For this we must develop the necessary physical and social infrastructure in such medium size towns and evolve a suitable system of incentives to attract industry and business to such towns.

Traffic Management Measures

Several traffic management measures can be undertaken to improve traffic flow and thereby increase fuel efficiency. In particular we need:

- improved traffic regulation systems and enforcement of traffic rules
- grade separation of fast and slow traffic, where possible
- exclusive busways at least along the main arterial city roads
- well designed arterial road intersections
- proper designed and maintained sidewalks and pedestrian crossings
- removal of all encroachments of pavements and roads

The congestion in some of the roads in the central business distincts can be relieved by:

- restraints of parking of cars in congested areas;

- area licencing fees for low occupancy vehicles entering congested areas;

- introducing car free zones on arterial roads in CBD where only public carrier vehicles would be allowed to operate.

Optional Modal Choice

We have seen in earlier sections the advantage of replacing personalised transport by public transport not only in terms of energy savings but also in terms of reducing road congestion and pollution.

A rail based system is of course the best for high density urban traffic. But such systems are highly capital intensive. Even so the traffic situations in 'jumbo' cities like Bombay, Calcutta, Delhi and Madras do justify rail corridors. Such a system should be immediately taken up for implementation in Delhi. The existing rail systems in other three 'jumbo' cities should be improved and expanded. The other cities would have to continue to depend on buses for mass transportation.

At present, urban development plans and designs do not give special consideration to mass public transport and non-motorised transport. In drawing up city traffic plans, specific measures should be built-in to facilitate the efficient operation of the public transit system. For example, exclusive lanes for public buses could be provided for in urban development plans. This, combined with the operation of a well-maintained public transport system would encourage more people to switch to public transport.

The city plans should also specifically provide for properly designed and maintained bicycle paths and pedestrian walks, in order to facilitate and encourage such forms of non-motorised transport.

Technological Development

We must increase the fuel efficiency of buses and trains. Buses in India are modelled around a truck chassis which is basically designed for long distance inter-city traffic.

We need buses designed specifically for intra city traffic. This would have a more efficient engine developing a torque at lower r.p.m. and attaining optimal fuel efficiency at lower cruising speed. The floor height should be reduced and the doors made wider for quicker passenger movements at stops.

Other alternative systems based on electricity, like the M-Bakn trolley bus, tram car and the light rail systems also need to be evaluated with reference to the specific requirements of each city.

6.3 TOWARDS RESOURCE CONSERVING CITIES

In the long run we have to move away from fossil fuels. We will have to plan for our cities to rely, to the greatest degree possible, on local, renewable sources of energy to meet their needs. While some R&D has been done in the development of solar devices and waste recycling systems they still are not cost effective and convenient for use(save perhaps for solar thermal hot water systems). R&D efforts in this area will have to be stepped upt substantially.

All cities produce wastes--garbage, sewages, waste water, etc. Today we spend energy and money to dispose them off. But we can convert this to valuable resources by recycling. Biogas can be produced from sewage sludge and garbage can be incinerated to produce electricity. Some pilot plants have been started. Can we expand this?

Urban planners should include energy as a major factor in their design and planning process. This would enable adopting an integrated approach in design of solid-waste disposal and energy systems. For example, low-cost sanitation systems in slum areas could be dovetailed with biogas systems to meet at least some part of the requirements of the colony. Urban design will have to move towards smaller urban subunits which are interconnected. Towns and neighbourhoods of the future will have to be designed on a self-reliant, resources-conserving basis making full use of renewable sources and recycled waste.

In the long-term, we must reduce dependence on an energy-intensive transportation network. This would imply encouraging lifestyles not integrally tied to such systems. It would involve recreating communities on a more human basis, where many of the day-to-day activities could be carried out within the walking or bicycling range, and where the relationship between home, work and shopping would be closer.

Planners and policy makers should have the vision to adopt such an approach in their urban and energy planning policies to build a sustainable humane urban society and not be helpless spectators to urban decay.

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ANNEX I

STUDIES ON URBAN HOUSEHOLD ENERGY

Study done by	Year of survey	Year of Publication	Towns covered	Remarks
1. NCAER	1977-78	1985	All India 312 towns	Total sample about 12,000 households both urban & rural incl. 4685 urban households. Focus on kerosene usage.
2. M Alam et al.	1981	1985	Hyderabad	Focus on fuelwood use and trade.
3. A.K.Awasthi et al.	1980-81	1981	Rewa	Focus on fuelwood.
4. A.K.N.Reddy et al.	N.A.	1983	Bangalore	Focus on supply, transportation, distribution & use of firewood.
5. Nair et al.	N.A.	1985	8 towns in Maharashtra- Pune, Sholapur Nanded, Ahmednagar, Satara, Srirampur, Talegaon, & Junnar.	Covers household energy & energy for personal transportation & for public services.
6. MaCauley	1985	1987	Raipur	
7. R. Bhatia	1986	1986	Lucknow, Bulandeshahar.	Focus on urban poor
8. Bowonder	N.A.	1987	Hyderabad	All fuels.
9. TERI	1987	1988	1000 Households in 10 towns- Delhi, Madras Jabalpur, Jaipur Chowdhar and five satellite towns.	All fuels. Appliances ownership also covered.

A brief description of the surveys that were considered for the micro level comparison is given below:

1. **N.S. Nair and J.G. Krishnayya - "Energy Consumption by Income Groups in Urban Areas of India".**

This study was financed by the Government of the Netherlands and is part of a series on the social implications of energy policies in developing countries carried out within the framework of the Technology and Employment Programme of the ILO.

This study was carried out to obtain data on the patterns of household energy consumption for different income levels in urban areas of India. In the survey conducted as part of the study, group of small towns with populations between 15 to 100 thousand from the Maharashtra state were considered.

The towns surveyed were·

1.	Junnar	:	18,310
2.	Talegaon	:	22,508
3.	Shrirampur	·	55,495
4.	Satara	:	83.604
5.	Ahmednagar	:	181,239
6.	Nanded	:	190,829
7.	Solapur	:	514.461
8.	Pune	:	1,685,300

2. **Molly K. Macauley's - "The Transition to Commercial Energy in Developing Countries: A Case Study of Households in Indian cities".**

This study investigates this sectoral transition in Raipur City of Madhya Pradesh. The focus of the study is on the use of energy for cooking. Using households survey data, the study identified patterns of commercial and traditional energy consumption as determined by relative prices of energy, family income and family size.

3. **Manzoor Alam et.al - "Fuelwood in Urban Markets".**

This book is based on a case study of fuelwood market supplying Hyderabad, India. It examines some of the important questions relating to urban fuelwood use. The study focussed on the following aspects:

a. Estimating the quantity of firewood and charcoal arriving in Hyderabad;

b. Analyzing the organization and structure of this trade;

c. Analysing energy consumption patterns among households and commercial users and,

d. Projecting fuelwood consumption to the year 2000.

4. Tata Energy Research Institute - "Urban Household Energy Survey", TERI conducted surveys in ten cities of India. Of these 10 cities, data for six cities was specifically analyzed for the purpose of this study. Six cities studied were:

    i) Delhi
    ii) Madras
    iii) Jaipur
    iv) Jabalpur
    v) Sahibabad (Satellite town of Delhi)
    vi) Sanganer (Satellite town of Jaipur)

    This survey was conducted to estimate energy consumption end-use wise by types of activities/device and the mix of fuels consumed by different income classes in these cities.

ANNEX 2

Conversion values used for finding gross energy and 'useful' energy

Energy Source	Unit	Calorific value k cal) per unit	Efficiency of end use (%)
LPG	kg	11750	60
Kerosene	litre	8950	40 (for cooking) 1 (for lighting)
Soft coke	kg	5770	20
Electricity	kWh	860	10 (for lighting)
Firewood	kg	4750	10
Agricultural Waste	kg	4200	8
Dung Cake	kg	2400	8
Charcoal	kg	5000	25